

Contributions to end global hunger



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Canada



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A synthesis of the Canadian
International Food Security
Research Fund (CIFSRF)
2009–2018



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Recommended citation: International Development Research Centre. 2018. *Contributions to end global hunger: A synthesis of the Canadian International Food Security Research Fund (CIFSRF) 2009–2018*. Ottawa, Canada.

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Photo credits:

Cover photo:

Tumsifu Lucas Sanga texts other farmers to discuss what she and Isac Daniel Nkyani have seen in the soybean field, Makete, Tanzania.

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Message from Global Affairs Canada Deputy Minister of International Development

Diane Jacovella

Global Affairs Canada is pleased to celebrate nine years of successful collaboration with the International Development Research Centre (IDRC) to achieve improved food security through innovation and experimentation. The Canadian International Food Security Research Fund (CIFSRF) initiative has been one of Canada's flagship programs, promoting innovation in development through applied science and technology.

CIFSRF is an example of what it means to “make Canada a leader in development innovation and effectiveness” and to “experiment with new approaches to existing problems and measure the impact of their programs.”

This synthesis report focus is on learning from the CIFSRF experience and identifying key lessons that can be applied to future programming. It consolidates the accomplishments and challenges of a diverse range of initiatives by examining common outcomes: improved nutrition, increased incomes, gender integration in research and development, and policy influence.

CIFSRF has been a source of motivation and support for Canadian universities to rebuild their international agricultural programs and establish partnerships with developing country organizations. It has brought renewed credibility and visibility to Canada as an actor in international agricultural research for development. The report highlights the impressive and enduring teamwork that emerged when talented researchers from institutions across Canada were brought together with counterparts in the South. The collaboration that ensued in the development of nutritious foods, animal vaccines, and creative production and processing practices has changed the lives of millions of people. Some of these innovations will have global reach.

Moreover, I was pleased to see this report examine how CIFSRF promoted gender equality and the empowerment of women and girls. In least developed countries, 79% of women identify agriculture as their primary source of income, and women produce 50% of the world's food. Yet women in the agricultural sector lack access and control over assets in comparison to male counterparts. CIFSRF effectively integrated gender as a cross-cutting theme by ensuring equal access for women to the benefits of the project, including as researchers, trainers, farmers, small business owners, and consumers. By recognizing women as agents of change within the agricultural sector, the project actively contributed to improving diets, advancing economic development, influencing policy change, and shaping the dialogue on food security within their countries.

CIFSRF pioneered new forms of partnerships among public, private, and not-for-profit stakeholders, but also with local business communities, resulting in the commercialization of new products. The lessons drawn from these public-private partnerships can provide guidance to policymakers and development practitioners, including Global Affairs Canada, on how to best leverage private sector investment in development programming, which is so important if we are to meet the Sustainable Development Goals and leave no one behind.

As you will see from reading this report, CIFSRF was closely aligned with Canadian international aid and development priorities and positions both Global Affairs and IDRC to make a major contribution to the goals of the Feminist International Assistance Policy. I would like to take this opportunity to thank all the CIFSRF research organizations and partners who work tirelessly to help us make the world more peaceful, more inclusive, and more prosperous.



Message from IDRC President Jean Lebel

The Canadian International Food Security Research Fund (CIFSRF) was born in the wake of the 2007 global food crisis – a moment that galvanized the world's attention to food security, nutrition, and agriculture.

The severity of the crisis called for solutions targeting immediate impact, but also those focused on long-term, sustainable change. Recognizing this, the Government of Canada launched CIFSRF through IDRC and Global Affairs Canada. Its mission was to combine expertise from Canada and the Global South to conduct applied, collaborative, and results-oriented research to improve the lives and nutritional security of smallholder farmers, particularly women.

Nine years later, CIFSRF has much to celebrate. The solutions developed with funding from CIFSRF have reached 78 million people. This includes people consuming better, healthier food and farmers benefiting from improved income and productivity, reduced drudgery, and strengthened capacity.

CIFSRF was committed to expanding and adapting solutions. Of the 144 innovations developed and tested, the 36 most promising ones were scaled up to reach thousands, and in some cases millions, of people.

Understanding how and when to make the benefits of proven solutions available to large numbers of people is vital to overcoming society's greatest challenges, as articulated by the Sustainable Development Goals. CIFSRF produced hard evidence of what works and what doesn't, and how what works can be taken to scale.

Research is at the core of innovation and scaling up solutions. For instance, Indian and Canadian researchers discovered how to fortify iodized salt with encapsulated iron. Iodized salt has contributed to nearly eradicating iodine deficiency. This innovation seeks to do the same for iron deficiency, which affects about 2 billion people. CIFSRF funding helped the researchers take the innovation to scale. Double-

fortified salt has so far reached millions in India. Anemia rates are dropping among those consuming it, and distribution is accelerating.

Such innovations are dependent upon skilled researchers at both the global and local levels. CIFSRF made a transformative investment in building the capacity of researchers and graduate students in Canada and around the world. For example, CIFSRF fostered opportunities for 406 graduate students, 235 of whom are women. CIFSRF researchers from Canada and the Global South have been recognized with awards, promotions, and other forms of career advancement.

CIFSRF leveraged the research capacity of IDRC and the program strength of Global Affairs Canada to help advance Canada's international assistance policy. The program recognized that women and girls are less food secure than men and boys despite being the main food producers in developing countries. CIFSRF projects developed solutions and strategies that engaged women and girls as the primary agents of change, and ensured that women were the main program beneficiaries. For example, 42% of the farmers involved in the research were women.

This report demonstrates how enhanced food security changes lives for the better. Families benefit from higher income, women benefit from improved autonomy over resources and decisions, and governments and development agencies have the evidence they need to develop effective policies and programs.

Millions of people worldwide are living healthier, more prosperous lives thanks to research supported by CIFSRF. Through sharing the program's results and lessons learned, we hope to facilitate opportunities to reach millions more.



Overview





Nine years ago the Government of Canada, through the International Development Research Centre (IDRC) and Global Affairs Canada, decided to push the boundaries of research and development by establishing the Canadian International Food Security Research Fund (CIFSRF) to generate practical innovations that would improve the lives of the poor and food insecure.

This CIFSRF synthesis represents the collective work of the many people who dedicated their time and expertise to the goal of developing and scaling up innovations that increase the production, access, and consumption of safe and nutritious food. Farmers and community members were at the forefront of the effort to validate and test food security innovations. Research teams developed those innovations and found the necessary financial resources and partnerships to bring them to life.

Why CIFSRF?

The global food price crisis of 2007–2008 refocused the development sector's attention to food security and international agricultural research, which ultimately prompted the establishment of CIFSRF. When the Government of Canada reformed its approach to the International Assistance Envelope in 2009 and identified food security as one of Canada's top international assistance priorities, it found many partners ready to work with it.¹

CIFSRF was established as a partnership between IDRC and Global Affairs Canada to contribute unique and innovative ideas to improve food and nutritional security. People are considered food secure when they have access to sufficient, safe, nutritious food at all times in order to maintain a healthy and active life.

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Enjoying EcoSun nutrient-enriched porridge as an afternoon snack in school. Quang Kim Kindergarten. Quang Kim, Bat Xat, Lào Cai, Vietnam.

Food security is often assessed by three pillars:

- **Food availability** — Food must be available in sufficient quantities and on a consistent basis. CIFSRF focused on sustainably increasing agricultural production.
- **Food access** — People must be able to regularly acquire adequate quantities of food through purchasing, bartering, gifts, borrowing, or food aid. CIFSRF focused on increasing incomes and access to markets.
- **Food use** — Food that is consumed must have a positive nutritional impact on people, and entails cooking, storage, and hygiene practices within the household. CIFSRF focused on improving nutrition.

A fourth pillar, **stability**, refers to the need to have the other three pillars in place consistently over time.² Regular access to adequate and healthy food can be variable for many due to unpredictable weather, political instability, or economic changes. It is important for food security efforts to recognize all of these elements if they are to improve people's lives in the long term.

With this in mind, CIFSRF was founded with three objectives:

- Increase food security in developing countries by funding applied research in agricultural development and nutrition.
- Build partnerships between Canadian and Southern organizations, researchers, private and public sectors, and civil society to address food security.
- Use research results to inform food security policies and programs.

These objectives guided the first phase of CIFSRF (2009–2013), when more than 144 evidence-based food security innovations were developed and field tested. CIFSRF's second phase (2013–2018) focused on scaling up the 36 most promising innovations to benefit a large number of smallholder farmers (especially women) and food consumers, while helping to improve global food and nutrition security.

CIFSRF Phase 2 thus added a fourth objective:

- Identify innovations and scale up the most promising research results.

CIFSRF was a partnership between IDRC and Global Affairs Canada to address the challenge of global hunger.

The two phases funded 39 projects involving 20 Canadian and 40 Southern organizations that carried out research in 24 Southern countries and in Canada.

The world needed CIFSRF's focus on research and innovations to tackle global food and nutrition insecurity. When it was launched in 2009, the effects of the global food price crisis and the ensuing global financial crisis were deeply felt. More than 1 billion people were chronically undernourished, up 8% from only two years earlier.³

There has been some progress since: the number of chronically undernourished people dropped to 821 million by 2017.⁴ However, food insecurity remains a major issue in most parts of the developing world despite this reduction.

Canada, along with other countries, has endorsed the UN Sustainable Development Goals (SDGs), otherwise known as Agenda 2030.⁵ SDG 2, which calls for ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture globally, is the most challenging. SDG 2 has two key targets: to end hunger (SDG target 2.1) and to end all forms of malnutrition (SDG target 2.2). CIFSRF is contributing to Canada's role towards ending both.

From the beginning, CIFSRF was designed to foster collaboration across sectors and between Canadian and developing country research experts. This collaboration has created innovations and networks that live on and will continue to contribute to global efforts to address food and nutrition insecurity well beyond the official end of the initiative and its CA\$124 million investment.

Synthesis report: Celebrating results, promoting partnerships

The breadth and depth of the projects made it challenging to streamline results. Therefore, this synthesis takes the approach of reflecting the diversity of the projects and the wide scope of their impact.

Broadly, this report answers two questions, dividing the synthesis into two parts:

- 1) What did we achieve?
- 2) How did we achieve it?

The first question is addressed in the first three sections, on agricultural productivity, nutrition and income. An estimated 78 million people were reached by CIFSRF's work, an impressive figure for a relatively small program.

The second question is addressed in the following three sections, on the cross-cutting themes of gender equality, scaling up, and partnerships. The synthesis concludes with a brief look at the road ahead.

While this synthesis is comprehensive, the sections were also meant to be used as stand-alone sections, so readers will find some repetition when they read cover to cover.

Each section opens with highlights of aggregated numbers and results from the program relevant to that section's theme. This is followed by a short summary of the issue, an introduction to how CIFSRF as a program and its projects approached the issue, a summary of the key results, and a selection of best practices resulting from the work. Each section features one project box to demonstrate how a particular theme was addressed.

The productivity, nutrition, and income sections (sections 1 to 3) contain a table at the end which highlights some of the research results and impacts. The complete set of findings and publications from each CIFSRF project can be found in the IDRC Digital Library's [CIFSRF collection](#), or by visiting the project pages on the CIFSRF website. A complete list of CIFSRF projects, with links to their website pages, can be found at the end of this document.

CIFSRF was explicitly set up as a fund that would use competitive calls to identify and select the best research ideas from strong and capable teams. It was also explicitly intended to be broad-based and open to any research that could contribute to improved food security. This resulted in a strong and diverse portfolio of projects that used diverse strategies and achieved diverse outcomes.

Traditionally, research projects focus their work within one thematic area, such as nutrition, agricultural productivity, income, or environmental sustainability. CIFSRF's research partners took a unique and overdue approach to their projects — if the ultimate goal is to improve the lives of people who are poor and food insecure, then projects must be designed to sustainably address all factors that contribute to poverty and food insecurity. For instance, an innovation that improves crop yields and boosts incomes may have an immediate and positive impact, but if it also increases soil degradation, then the long-term impact may entrench poverty and food insecurity even further.

Although this system approach is common sense, it is rarely common practice.



▲ A farmer tends to his fish pond in Cambodia, where small-scale aquaculture combined with homestead vegetable gardens is increasing and diversifying diets for low-income households.

Methodology

CIFSRF's monitoring system was based on the program logic model, which was refined throughout the initiative. A set of 39 high-level common indicators were used to track program progress across the portfolio of projects. Indicators were both qualitative and quantitative to capture progress on scaling innovations, adding evidence and credibility to the program understanding.

The diversity of projects meant that aggregating thematic numbers across projects was not possible. Indicators were applied to each project depending on the innovation and context for measuring and reporting on productivity, income, or nutrition gains. This balance between project-level and program-level indicators was deemed to be the appropriate approach to capture change and impact; it shares common ground with other approaches.⁶ Applying indicators to complex and diverse projects demonstrated three lessons: that fewer is better, that qualitative indicators are just as valuable, and that it is important to develop suitable indicators for research processes such as capacity changes, not just development impacts.

The complexity of CIFSRF's projects also presented challenges to synthesize results, approaches, and best practices across the program. The process to develop this synthesis report began in 2017, when IDRC and Global Affairs Canada undertook a number of activities to consider CIFSRF's broader achievements. Working with the Overseas Development Institute (ODI), the program conducted an early impact analysis to, as much as possible, evaluate results towards food security impacts, consider the extent to which CIFSRF projects contributed to observed and potential results and impacts, and determine to what extent the activities and gains are likely to be sustained and scaled up.

ODI's analysis also addressed CIFSRF's first objective, "Increase food security in developing countries by funding applied research in agricultural development and nutrition," which relates to the three pillars of food security and forms the basis of the first three sections. The full ODI reports are available in IDRC's



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Digital Library: Understanding the CIFSRF phase two portfolio's contribution to [sustainable increases in productivity; improved nutrition; generating income; and overall contribution to food security](#).

Working with KIT Royal Tropical Institute, the program conducted a synthesis of the approaches that projects used to integrate gender effectively into research and examined their outcomes and lessons. CIFSRF explicitly focused on women smallholder farmers as the primary agents of change and end-users of the research. The program's approach to gender integration evolved across the nine years and is captured in section 4. The full KIT reports are available in the IDRC Digital Library: [Typologies of change](#) and [Gender integration lessons learned](#).

Scaling up innovations was the fourth objective, in Phase 2: "Identify innovations and scale up the most promising research results." This was a critical component that required programming to be directed towards increasing knowledge, developing food security innovations, and achieving meaningful and measurable development results. Particular attention was paid to long-term sustainability of the scaled-up innovations. An IDRC reflection on the

▲ Priority Household book, where the monthly allotment of double-fortified salt by the Public Distribution System is tracked, Jharkhand, India.

process with the research teams resulted in section 5. Other white papers and journal articles from IDRC on scaling are forthcoming, and many of the research teams have already submitted articles on their scaling processes and lessons for publication.

Partnerships were the focus of CIFSRF's second objective, "Build partnerships between Canadian and Southern organizations, researchers, private and public sectors, and civil society to address food security"; this is covered in section 6. The approaches, results, and lessons in this section were the culmination of nine years of experience and insight in working on multi-sectoral and multidisciplinary partnerships. The complexity of issues surrounding food and nutrition security initiatives required complex approaches and the combining of the skills, resources, and expertise of many people and organizations. Capacity building and spaces for learning were felt to be an equally important indicator of success of the impact of research, but one that is sometimes undervalued.

CIFSRF's third objective, to "Use research results to inform food security policies and programs," is discussed throughout the synthesis, with the key policy changes captured on the centrefold map. Projects used different approaches to inform policymakers and decision makers, including regularly sharing information on activities with government agencies to coordinate field activities, raising awareness of new innovations, gaining approval of technical innovations by regulators, amending or impacting new laws to confer rights and responsibilities, convincing ministries to adjust their

Applying indicators and assessing impact across complex and diverse projects was challenging.

priorities or to undertake additional programs, and coordinating with government public procurement as a channel to scale up innovations. All projects engaged with policymakers and opinion formers; these efforts resulted in 72 policy briefs. By the end of the program, 10 countries had developed 29 food security policies, plans, and programs that directly reflected or used the results of CIFSRF.

The final section, entitled "The road ahead", considers the strategic directions required to reframe agriculture and food systems to address current challenges. This includes gender transformative approaches to agriculture to address the root causes of inequalities; offer greater collaboration across all sectors; consider the shifting demographics of youth; and improve the efficiency, environmental resilience, and inclusivity of food systems all along the value chain to address the needs of both small-scale farmers and urban consumers.

Across these diverse projects were discussions about how to balance research, capacity building, development impact, and partnerships. Among the lessons learned are that teams and donors should not underestimate the time needed to carry out the diversity of activities under the umbrella of collaborative research.

1 FAO. 1996. Rome Declaration on Food Security and World Food Summit Plan of Action. Rome: Food and Agriculture Organization of the United Nations.

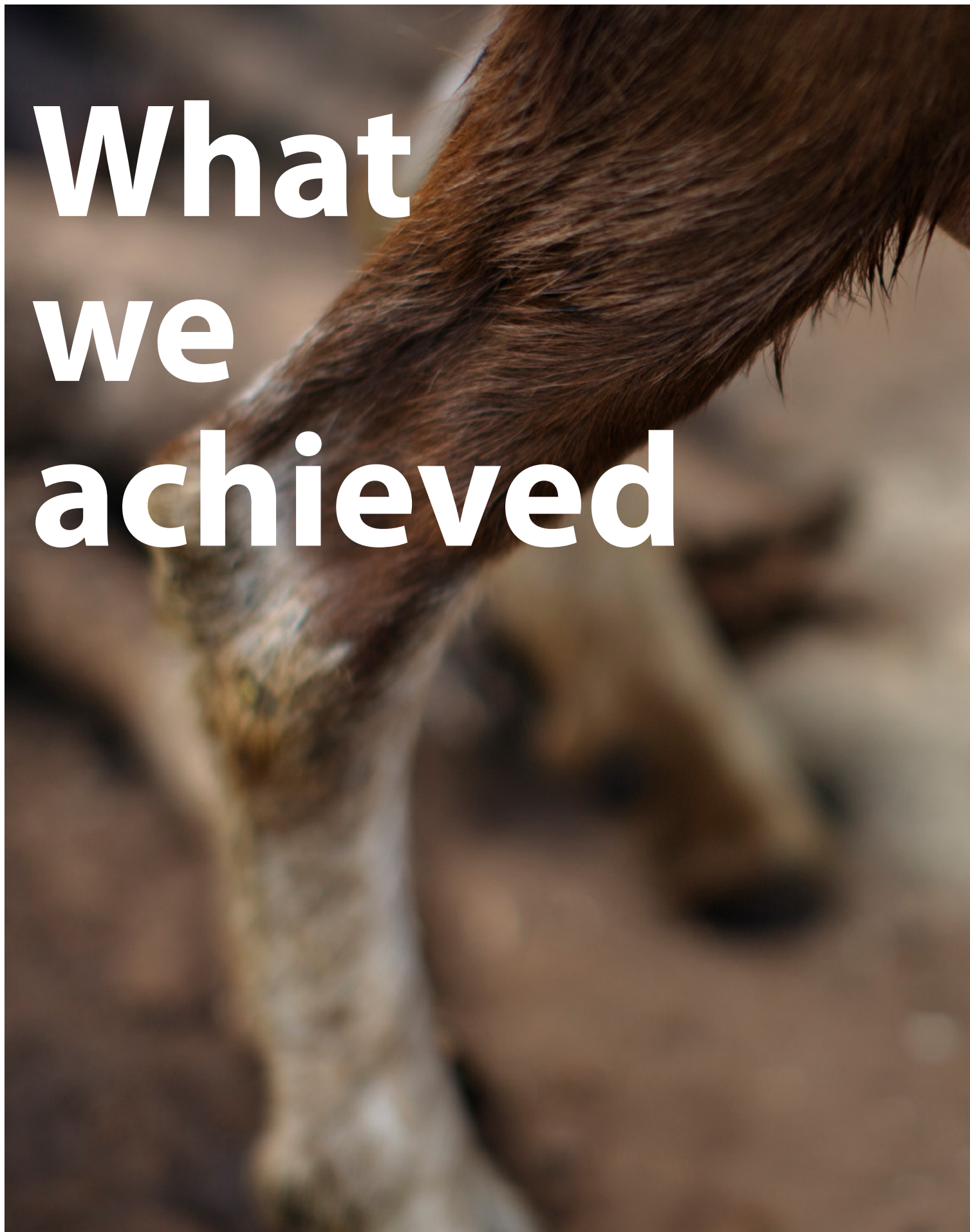
2 FAO. 2009. Declaration of the World Food Summit on Food Security. Rome: Food and Agriculture Organization of the United Nations.

3 FAO. 2009. The State of Food Insecurity in the World. Rome: Food and Agriculture Organization of the United Nations.

4 FAO, IFAD, UNICEF, WFP, and WHO. 2018. The State of Food and Nutrition Security in the World: Building climate resilience for food security and nutrition. Rome: Food and Agriculture Organization of the United Nations.

5 United Nations. 2015. Transforming our world: The 2030 Agenda for Sustainable Development. United Nations Sustainable Development knowledge platform.

6 IDIA. 2017. Insights on Measuring the Impact of Innovation. The International Development Innovation Alliance.



**What
we
achieved**



1

Sustainably increasing agricultural productivity





Approaches

Two approaches were used to increase sustainable agricultural production.

Yields and acreage increased by

- participatory testing innovations with farmers
- scaling up innovations through extension
- reducing pre- and post-harvest losses

Environmental sustainability improved by

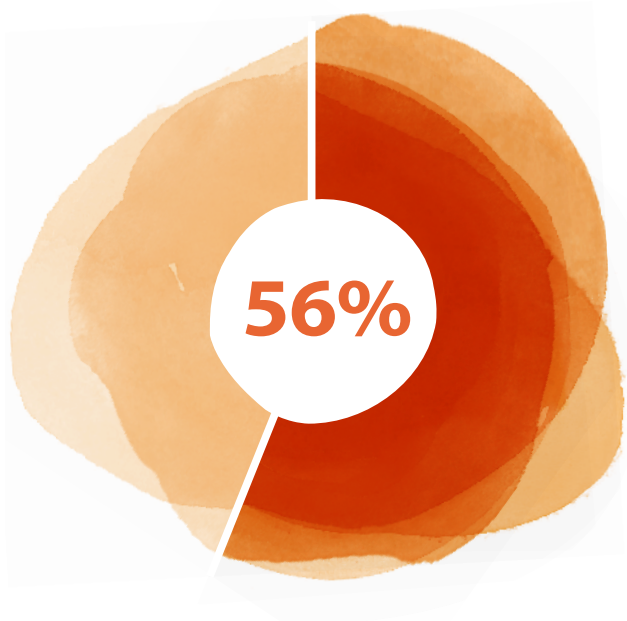
- sustainable land and/or livestock management
- integrated water resource management
- protected and enhanced biodiversity



Best practices

- Continue to provide reliable new technical and social innovations through scientific research and test them with farmers and other stakeholders
- Recognize the ongoing investments required to sustain productivity gains among smallholders
- Ensure that viable markets can absorb enhanced yields
- Engage policymakers to sustain gains in productivity

Results



of Phase 2
projects focused
on increased
agricultural
productivity

More than
1 million people,
mainly smallholders,
benefited from
increased productivity

Yields significantly
increased with improved
varieties and practices:
for example,

- homestead gardeners
in Cambodia produced
66% more fruit,
53% more large fish,
18% more eggs,
and **11%** more poultry
than non-participating
households

Expanded viable land for
cultivation: for example,

- total area under
cultivation of indigenous
vegetable production
is now more than
80,000 hectares,
representing a net
increase of **161%**
in Benin and **768%**
in Nigeria

The world population is expected to reach 10 billion by 2050: food production will need to increase by 50% globally just to keep pace.¹

[Sustainable Development Goal 2](#) (SDG 2) calls for doubling the agricultural productivity and incomes of small-scale food producers by 2030, with a special focus on women, indigenous peoples, family farmers, pastoralists, and fishers. SDG 2 also highlights the need for sustainable food production systems and resilient agricultural practices to maintain ecosystems and strengthen farmers' adaptive capacity.²

The challenge is particularly acute in developing regions where constraints such as land degradation and nutrient loss, water scarcity and poor water resource management, pollution, low-performing genetic resources, and the spread of pests and disease compromise the productivity of agricultural systems.

Improving agricultural productivity relates to the first of four pillars of food and nutrition security (see Overview section): the availability of and access to a range of foodstuffs and the stability of their supply. The challenge is achieving increases in yields and quality in economically and environmentally sustainable ways.

Approaches

At the program level

The Canadian International Food Security Research Fund (CIFSRF) is working towards its ultimate aim of increasing environmentally sustainable food security for the most food insecure. Two of the immediate objectives in its logic model (see Overview section) were particularly relevant to sustainably increasing agricultural productivity:

© SAK Nepal / Roshan Pudasaini



Using a hand-held tool to remove corn from the cob, reducing the amount of time and effort to carry out the task by hand, Nepal.

- Increase global, national, and local knowledge of new or underused environmentally sustainable, gender-sensitive research applications and scaling-up models that increase agricultural productivity and the nutritional value of food in developing countries.
- Improve the ability of public and private sector organizations in developing countries to implement and support environmentally sustainable and gender-sensitive food security innovations, with an emphasis on enhanced participation and decision-making roles of women and of women subsistence farmers alongside men.

CIFSRF's environmental strategy was cross-cutting. It highlights sustainable land management, integrated water resources management, and protection and enhancement of biodiversity. Program objectives emphasized both the economic and social sustainability of increased production along with its environmental sustainability.

Within projects

An analysis by the Overseas Development Institute (ODI)³ categorized CIFSRF Phase 2 projects into three main approaches, according to how they responded to the challenge of sustainably increasing agricultural productivity:

- **participatory field testing** of innovations that sustainably improve productivity: this involved researchers working closely with groups of smallholder farmers to design and run trials of new or underused varieties, technologies, or farming methods to raise yields and increase or diversify production
- **extension methods** to promote the diffusion of knowledge that sustainably improves production, either via information technologies (radio, text messages, etc.) or networks (input suppliers, government extension services, producer groups)
- **scale-up of cutting-edge innovations that reduce pre- and post-harvest losses** to increase productivity

Results

Because CIFSRF aimed to benefit the most food insecure people, it was important to assess who benefited from the innovations and how likely they were to be sustained.

In examining CIFSRF results, we looked for signs of

- increased productivity, to see if the innovations increased yields and/or acreage under production or have diversified the range of production
- who benefited and whether they can sustain the increases
- environmental sustainability

Examples of results from the projects with the most quantifiable contributions to sustainably increasing productivity can be seen in Table 1. Here we present highlights in the three key results areas.

Increased productivity

The 10 Phase 2 projects that primarily focused on sustainable increases in agricultural productivity helped farmers increase yields. Half of these projects placed equal emphasis on diversifying crops or livestock as a means of strengthening food security.

Six of these projects worked closely with farmers and local communities to **test and adapt technologies and techniques to local conditions through field trials**. In some cases these

were supported by the initial provision of seed, planting material, or hatchlings. All saw noteworthy gains in productivity, particularly where farmers' yields had been low.

For example, homestead gardens in Cambodia increased their yields by combining aquaculture with home gardens to diversify production for alternative sources of income and nutritious foods (see Table 1).



CIFSRF projects also expanded the area under cultivation using improved practices or varieties. In West Africa, where research focused on reviving and improving the cultivation of nutritious indigenous vegetables, the area under green leafy vegetable production increased by 161% in Benin and 768% in Nigeria.

Several of these projects tested approaches to deliver useful agronomic advice to rural audiences by **scaling up extension methods**. Four projects used radio, text message, and other communications technologies, while others worked with existing networks such as agro-dealers, agricultural extension services, and in the case of West African indigenous vegetables, even schools and prison farms. In Ghana, researchers pioneered [AgroTech SmartEx](#), a remote extension system that provides agronomic advice on improved practices for producing five key crops. Using radio and mobile-enabled communication applications, they reached roughly 500,000 farmers.



Four projects primarily focused on **reducing pre- and post-harvest losses**. Hexanal nanotechnology extended the harvest and shelf life of soft fruits in several settings while extending the harvest window for farmers to earn a better price in markets. In Kenya, pre-harvest treatments reduced fruit drop by up to 50% for sweet orange and 45.4% for mango. In Tanzania, mango fruit drop declined by 40%.



Two projects that focused on the development of novel vaccines for diseases affecting African livestock are also expected to bring major gains in productivity by reducing livestock losses when the vaccines become widely available. Once trials and licensing arrangements are completed, novel vaccines being developed by African and Canadian partners stand to reduce losses from diseases afflicting millions of African sheep, goats, cattle, and swine.

Projects worked closely with farmers and local communities to test and adapt technologies to local conditions.

Who benefited, and can they sustain the increases?

In total, CIFSRF Phase 2 projects that focused on agricultural productivity have directly benefited well over 1 million people. Most of these were small-scale, low-income producers, but others also benefited. Information about sustainable increases to agricultural productivity has been fed along the value chain: suppliers now have a more diverse range of inputs to sell, and agricultural extension agents, food vendors, and processors received training. Most projects reached similar proportions of men and women farmers, but overall women made up a higher proportion of trainees in post-harvest processing techniques. In Nepal, 72% of farmers trained in sustainable agriculture practices are women.

A key question is whether the low-income producers, suppliers, processors, and others in the food system can sustain these changes to benefit from increased production and productivity over the long term. As ODI notes in its analysis, behaviour changes that produced tangible benefits and that are relatively simple to adopt are more likely to be sustained over the long term.

As seen in section 3, a number of projects generated additional income that may (depending on household choices) provide a basis for smallholder farmers to continue the newly acquired practices and enjoy higher yields. Enhanced homestead food production in Cambodia, the scaling up of pulse innovations in Ethiopia and Tanzania, and Nepal terrace farming generated higher returns for farmers within one season. Indigenous vegetable growers in West Africa can produce gains in the very near term because of short cropping cycles, and in Bolivia, a whole new fish value chain in paiche leather is benefiting fishers, artisans, and vendors.



The improvements made in these projects are likely to be sustained because the results visibly increase yields and incomes.

The regulatory environment is an important consideration, especially for projects that introduced scientifically novel technologies, namely livestock vaccines and hexanal nanotech applications for fruit. These projects navigated challenging terrain to seek approvals for commercialization. Several projects, such as improved legume seed production in Tanzania and Bolivia fisheries management, contributed to the process of changing government regulations (see policy map), enabling farmers and fishers to benefit from potential productivity increases.

The research context typically provided expert advice and access to inputs. In some cases, it facilitated access to credit and other productive resources. All projects built the capacity of local organizations that have the potential to continue the work, such as investing in local research organizations with good connections to small-scale coconut producers in Côte d'Ivoire.

▲
A farmer admires her maize crop and shows the differences between two types of plants. She used lessons from the farmer evaluation plot (Watema), Makueni County, Kenya.

Environmental sustainability

As a whole, the CIFSRF Phase 2 portfolio covered three aspects of environmentally sustaining increased production:

- sustainable land and livestock management
- integrated water management
- protection and enhancement of biodiversity

As the long-term viability of productivity increases, it may be some years before CIFSRF contributions to environmental sustainability (improved soil fertility,

less erosion, improved water efficiency and infiltration, and reduced incidence and virulence of pest attack) can be fully appreciated.

Eight projects that focused on increasing productivity made noteworthy strides in promoting **sustainable land and/or livestock management** techniques.

They promoted a mix of improved technologies and management techniques consistent with the low-input approach to supporting agriculture for low-income farmers.



Extending pulse yields while protecting soils in Ethiopia

Research that builds on a 20-year partnership between the University of Saskatchewan and Hawassa University achieved significant gains for higher yields and incomes for farmers, household nutrition, and the health of soils.

Phase 1 research generated a number of successful innovations to increase pulse production levels, including improved pulse varieties, double cropping with pulses, and improved processing techniques and farming practices. Phase 2 research saw yields increase from 2 to 2.5 tons/hectare for chickpeas and from 1.2 to 1.5 tons/hectare for haricot beans. These results dovetailed with the Ethiopian government's second Growth and Transformation Plan, which targets an increase in chickpea production. The results were scaled up to reach more than 51,000 farmers.

Smallholders received seed and were trained to cultivate improved bean and chickpea varieties through the government extension system and existing farmer groups. Extension agents collaborated with farmer groups and model farmers to share improved cultivation techniques and varieties. The farmers who were selected to

produce seed were trained in additional post-harvest handling skills to ensure seed quality.

Introducing soil-nourishing chickpea as a double crop helped farmers mitigate the risk of crop failure, thereby stabilizing incomes. Adopting chickpeas enabled farmers to intensify their production using available land and labour. A survey about chickpea production conducted by the International Crops Research Institute of the Semi-arid Tropics found that the incomes of participating farmers in two rural districts increased by an average of CA\$164/year. In southern Ethiopia, where fertile land is limited, this enabled farmers to cultivate land that would have otherwise been left idle after growing cereals.

Partnerships with government bodies responsible for health, agriculture, and gender played a key role in reaching large numbers of farmers. These relationships, in particular with extension services, enabled an effective scale-up of the project. The project established a Regional Pulse Innovation Platform to bring all stakeholders together and link them with national platforms.

Most projects combined several techniques, such as protecting soil nutrients and organic matter content, controlling soil erosion, reducing the use of agrochemicals by laying manure, intercropping and relay cropping, and integrating pest management.

Integrated water resource management was a key focus for seven projects. In Bolivia, farmers were encouraged to construct ponds on previously degraded land for fish production and to use more sustainable aquaculture techniques. In Cambodia, water resources were managed through improving rainwater harvesting, while better irrigation techniques were promoted in West African vegetable production. Research activities in Colombia helped reforest and thus rehabilitate watersheds, which improved water infiltration and allowed streams to run year-round.



Five projects contributed to **protecting and enhancing biodiversity** by diversifying production. In Cambodia and Bolivia, fish farmers were encouraged to rear smaller indigenous species as well as the larger and potentially more productive commercial ones. In Bolivia, the project contributed to changing a law that regulates fishing land use to ensure the sustainability of native fish populations and prevent the incursion of invasive species.



Projects succeeded in sustainably increasing productivity because they were relevant to farmers and built on past performance.

Best practices

CIFSRF projects succeeded in sustainably increasing productivity because they were relevant to farmers and other stakeholders and they built on past performance. Earlier research had demonstrated that most of the farming technologies and practices being scaled up were a good fit for local farming systems and easy for farmers to understand and use.

The questions that remain are whether these successes can be sustained, whether they can be shared even more widely, and how extension services can be more effective.

CIFSRF experience highlights four factors that are key to sustaining increases in agricultural production:

- scientific research that can provide reliable new technical and social innovations and test them with farmers and other stakeholders
- development of local markets to sell the added yields
- ongoing advice and inputs to sustain yields
- policy influence

Scientific research should continue to provide reliable new technical and social innovations and test them with farmers and other stakeholders

Research must address a more complex world and respond to the new challenges of climate change, the management of increasingly scarce resources, conflict, and demographic changes while continuing to address the long-standing challenges of increased production and food quality. Evidence-based

innovations can enable rural smallholder farmers to dramatically reduce post-harvest losses, improve their adaptation to climate change, and ensure food security by improving their soil and water management, developing more resilient farming systems, growing crops better suited to the local environment, and improving their access to services — ultimately enhancing their own capacity to innovate.

For example, a Canadian–Nepalese research team tested a series of innovations with farmers to improve terrace farming. Among the trial innovations is GlnLux, a Canadian-engineered biotech invention that helps to improve legume crop yields and reduce the need for synthetic nitrogen fertilizers. Nitrogen is a key plant nutrient that plays a major role in achieving maximum yields, especially in protein-rich legume crops. Synthetic nitrogen fertilizers have transformed farming, but they are too expensive for poor farmers and they contribute to greenhouse gas emissions. The GlnLux biosensor offers farmers an affordable and easy way to test for and increase soil-based nitrogen, ultimately improving legume crops yields and helping to reduce protein deficient diets.

Major gaps remain in our understanding of how to get innovations and tools into the hands of poor or rural smallholder farmers, particularly those outside the reach of mainstream agricultural development. We need to understand the specificity of various contexts (ecological, socio-economic, cultural, and historical) as well as the challenges, opportunities, and drivers for positive change.

Enhanced yields need viable markets to make an appreciable contribution to food security

Small-scale producers the world over are at the mercy of the forces of supply and demand. Like others, CIFSRF-supported producers need the marketing infrastructure to reach customers and viable markets for their product. Sustaining increased yields will depend on parallel efforts to develop markets through consumer outreach and ongoing investments in infrastructure to ensure that products reach market.

Sustaining gains for farmers requires ongoing investment in advice, inputs, and engagement with policymakers.

Most projects had ready markets for the researched crops, but farmers in Tanzania faced a glut when they increased their soybean yields in 2017. To ensure market viability, several projects focused on commercialization strategies. In several cases this involved working with producer groups, which can play an important role in helping small producers access markets. Some projects worked with agro-processors and traders to strengthen local markets, as in the case of leafy indigenous vegetables in West Africa, while in the case of Bolivia, the research helped strengthen existing value chains for fish, create a new value chain for leathers, and expand the national market for fish through recipe demonstrations and fairs. Sustaining increased yields will depend on parallel efforts to sustain markets through outreach to consumers and ongoing investments in infrastructure to ensure products reach market.

Sustaining productivity gains among smallholders may require ongoing investment in advice and inputs

Smallholders involved in CIFSRF projects benefited from expert advice, participation in trials, and access to seeds and other inputs needed to increase their productivity. Even where new practices were clearly profitable, smallholders can sustain these changes only if they have timely access to the necessary inputs and technical support. Where there is no business case to support these, they may need ongoing public investment.

On the input side, several project teams improved the supply of certified seed (e.g. legumes in Tanzania). Others encouraged local seed production (e.g. West African indigenous vegetables) and strengthened access to a range of inputs (e.g. terrace farming in Nepal).



In terms of advisory support, four projects worked with different extension models. These models ranged from distance methods enabled by information communication technologies (ICTs) to face-to-face training and advice through existing networks. In terms of yields, evidence suggests that distance extension approaches work at scale and at a significantly reduced cost per capita, but these models may not be financially sustainable without external support. In Ghana, the SmartEx mobile app required significant up-front investment, while a Kenyan project that provided extension through Farm Shops is still working towards a break-even model. It is promising that farmers indicated their willingness to pay for the SmartEx mobile app advisory services in Ghana, but extension services will likely always require some degree of public investment.

Engaging policymakers is essential to sustaining gains in productivity

The regulatory environment and other areas of public policy play an important role in ensuring that productivity gains can be sustained in the long term and have the potential to scale. All 10 projects

had meaningful interactions with policymakers at different levels. This does not guarantee that lessons are integrated into national or regional policies, but some projects made tangible contributions to policy changes in various ways — going beyond simply changing written laws to building policymakers' capacities, access to networks, and demonstrated commitment to new agricultural concepts and approaches.

For example, CIFSRF research on legumes in Tanzania resulted in new seed regulations that call for fining fake seed producers. Beyond legal formalities, this change signalled the government's commitment to ensuring that the wider community trusts seed production systems.

Early and ongoing engagement with policymakers through research activities is never a guarantee of policy influence, but CIFSRF experience reaffirms lessons from other IDRC research — that engagement can make an important contribution to building policymakers' capacity to understand the complexities of agricultural innovation.

▲
A woman demonstrates how her farm has improved since using products of the sustainable agriculture kits, Nepal.

Table 1: Key CIFSRF Phase 2 contributions to sustainable increases in agricultural productivity

Project	Who benefited?	Productivity gains	Environmental sustainability
Bolivia: Fish for Food	1,030 families directly involved in fish farming (1,757 including those outside the core)	Fish-farming production increased six-fold from 811 to 4,805 tons/year in the core region	Worked with fishers and vendors to improve water and solid waste management
	379 indigenous fishers applied good practices introduced by the project	Number of ponds/producer rose from 3.4 to 4.6	New market for fish leather reduces waste
	New fish value chains benefit fish vendors, artisans, and restaurants	Paiche catch more than doubled, from 305 to 724 tons/year 8,400 ft ² of paiche leather produced	Facilitated community input into new fisheries law and agreement on improved fisheries management
Cambodia: Enhanced productivity and diversity of homestead gardens	17,500 farmers in 232 villages in 4 provinces diversified their gardens, poultry farms, and fish ponds, and increased yields	Enhanced gardens produced more fruit (507 vs. 306 kg), large fish (23 vs. 15 kg), eggs (117 vs. 99 units), and live birds (99 vs. 89 units)	Homestead gardening reached 96% of households (up from 61%). Improved practices included
		Participating families produced 28,000 kg of fish, 260,000 poultry eggs, and 6 million kg of fruits and vegetables for local consumption	<ul style="list-style-type: none"> ● water and soil conservation and appropriate fertilizer use ● increased crop diversity, with a choice of 15 fruits and vegetables
		Fingerling fish production increased by 30%.	232 model village farms serve as knowledge hubs on environmentally safe farming practices
Colombia: More nutritious and higher-yielding potatoes	4,061 farmers (48% women), directly and indirectly involved, growing new varieties	New improved varieties now grown on 16% of land cultivated with yellow potatoes (734 hectares)	87% of farmer field school participants reduced agrochemical use; 62% adopted soil protection practices
	133 growers producing improved varieties of seed potatoes	Certified seed tuber yield of 2,612 tons across seven regions	160 household gardens prioritized organic practices and native crop types

Project	Who benefited?	Productivity gains	Environmental sustainability
Côte d'Ivoire: Prevention of coconut losses from lethal yellowing disease	<p>Potential benefit to millions of coconut farmers at risk from lethal yellowing disease</p> <p>10 field schools trained 1,960 farmers and 180 extension agents on proper coconut farming and disease management</p> <p>6 women's groups formed</p> <p>9 plant clinics reached 671 farmers, villagers, and processors</p>	<p>Disease-affected trees yield no more than 15 nuts/tree/year. Healthy trees were estimated to yield 104 nuts/tree/year (593% increase), 240g of copra/nut, and 3.5 tons of copra/hectare/per year</p> <p>Improved techniques may decrease the 85% infection rate of lethal yellowing disease in Côte d'Ivoire by half</p>	<p>Protection of biodiversity: Côte d'Ivoire hosts one of only five international coconut gene banks</p> <p>Mitigation plans include techniques to limit soil erosion caused by burning diseased trees</p>
Ethiopia: Scaling up pulse innovations	<p>51,000 smallholders (42% women) improved production of common beans and chickpeas</p> <p>246,000 households reached by radio</p> <p>665 seed-producing clusters organized (3,324 farmers)</p> <p>9 seed-producing cooperatives established</p> <p>Local processor Guts Agro produced chickpea snacks, primarily sold by women vendors</p>	<p>Increase in yields from 2.0 to 2.5 tons/hectare for chickpeas and from 1.2 to 1.5 tons/hectare for haricot (common) beans</p>	<p>Introduction of double cropping with chickpeas increases land productivity with minimal water use and enhances soil fertility</p>

Table 1 (cont.): Key CIFSRF Phase 2 contributions to sustainable increases in agricultural productivity

Project	Who benefited?	Productivity gains	Environmental sustainability
Ghana: Using ICTs for agricultural extension	<p>Agronomic advice extended to 500,000 farmers (486,000 reached by radio, 14,000 by mobile-enabled agents)</p> <p>264 buyers and 234 buyer agents were trained and received advice to improve production of 5 key crops (maize, rice, cowpea, yam, soya)</p> <p>234 field agents trained in AgroTech's SmartEx mobile app technology</p> <p>82% of non-participants and 94% of participants willing to pay for SmartEx services</p>	<p>230% increase in maize production per farmer among radio listeners (from 919 kg to 2,208 kg)</p> <p>Women radio listeners had higher yields than non-listeners (2.25 tons/hectare vs 0.99 for maize; 2.39 tons/hectare vs 1.95 for rice)</p>	
India, Kenya, Sri Lanka, Tanzania, and the Caribbean: Nanotech innovations to extend fruit harvests and prevent losses	<p>4,360 farmers in India (81% small or marginal farmers; 32% women) received advisory services</p> <p>2,000 model farms established in Tamil Nadu with 3 knowledge hubs reaching an additional 25,000 farmers</p> <p>44 value-added trainings given with 83% women participants (926 women and 183 men); 35% of the women became small entrepreneurs</p>	<p>Effects of the Extended Freshness Formula (EFF) hexanal nanotechnology:</p> <ul style="list-style-type: none"> ● India: EFF spray reduces mango losses by up to 10% ● Kenya: EFF spray reduces sweet orange fruit drop by up to 50% and mango fruit drop by 45.4% ● Tanzania: EFF spray reduces mango fruit drop by 40% ● global: EFF post-harvest dips extend shelf life of a range of fruit by 12–18 days; reduces disease incidence by 80% 	<p>All hexanal and EFF ingredients are biodegradable and pose no threat to the environment</p> <p>EFF sprays replace crop-loss treatments that have known harmful effects (e.g. smoke exposure)</p> <p>Banana fibre fruit wrap can replace Styrofoam packaging currently used in storage and transport</p>
Nepal: Sustainable terrace farming	<p>64,795 farmers (79% women) received sustainable agriculture kits that reduce drudgery, increase production and income, and enhance environmental sustainability</p> <p>Up to 260,000 people directly or indirectly benefited</p>	<p>Vegetable production and consumption increased by 26%</p> <p>Legume yields increased by more than 25% when grown on previously unused terrace walls</p> <p>Yield per hectare increases from intercropping:</p> <ul style="list-style-type: none"> ● maize-cowpea: 26% ● millet-soybean: 26% ● mustard-pea: 30% 	<p>Improved land-use management to increase yields and maximize land use while preventing erosion on steep terrain</p> <p>1,057 farmers directly involved in testing; 74% are continuing sustainable agricultural practices</p>

Project	Who benefited?	Productivity gains	Environmental sustainability
Tanzania: Improved legume production	<p>650,000 farm household members (40% women) received information about integrated legume technologies; 129,000 farmers adopted at least one innovation</p> <p>1,682 farmers trained in improved techniques on 32 demonstration plots: an estimated 19,000–20,000 influenced by training days</p> <p>341 rural agro-dealers and extension officers at retail level trained on improved seeds and technologies</p>	Project produced more than 30 tons of certified seed and 24 tons of basic seed of promoted varieties	The adoption of best available agronomic practices on common beans and soybeans improves soil fertility, minimizes fertilizers and losses, and helps prevent erosion
West Africa: Indigenous vegetables and micro-dose fertilization	<p>Involved 338,000 smallholder farmers (51% women)</p> <p>21,000 vegetable traders sold indigenous vegetables (65% women in Nigeria and 72% women in Benin)</p> <p>561 processors in Nigeria (62.5% women) and 12,600 in Benin (98% women)</p> <p>618 seed suppliers in total</p>	<p>Leaf yields of micro-dosed vegetables increased 46–57%</p> <p>More than 80,000 hectares under cultivation, with indigenous vegetables representing a net increase of 161% in Benin and 768% in Nigeria</p> <p>Radio programming has reached 18 million listeners</p>	<p>Identified optimal rates of fertilizer micro-dosing in combination with organic manure for minimal soil residues</p> <p>Water savings of approximately 2.2 million litres/hectare (rainforest) and 8 million litres/hectare (savanna) by using micro-irrigation</p>

Source: Abridged and updated from Wiggins, S., Keats, S., Löwe, A., and Shaxson, L. 2018. Understanding the CIFSRF Phase 2 portfolio's sustainable increases in agricultural productivity. London: Overseas Development Institute. <http://hdl.handle.net/10625/57231>.

1 FAO. 2017. The State of Food Security and Nutrition in the World. Rome: Food and Agriculture Organization of the United Nations. <http://www.fao.org/state-of-food-security-nutrition>.

2 See targets 2.3. and 2.4 of SDG 2. <https://sustainabledevelopment.un.org/sdg2>.

3 Wiggins, S., Keats, S., Löwe, A., and Shaxson, L. 2018. Understanding the CIFSRF Phase 2 portfolio's sustainable increases in agricultural productivity. London: Overseas Development Institute. <http://hdl.handle.net/10625/57231>.





2

Integrating nutrition outcomes into agricultural development

Approaches

The main pathways to scaling up nutrition included

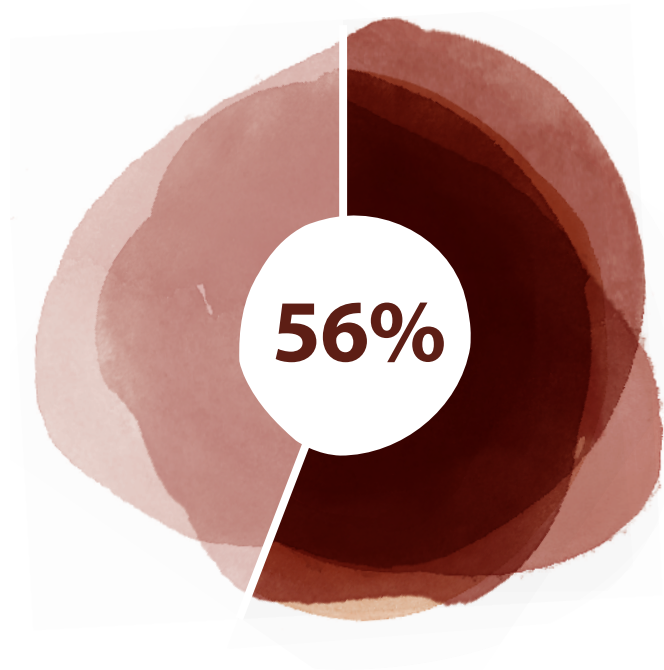
- dietary diversity and more nutritious crops
- food fortification and value-added processing
- nutrition education and promotion



Best practices

- Adopt an intentional focus on nutrition within agricultural interventions to improve nutritional outcomes
- Engage with policymakers and the private sector, especially when applying value-added food fortification pathways
- Recognize that nutrition education plays a vital role in linking agricultural development to nutritional outcomes
- Consider gender roles in designing nutrition-sensitive agricultural interventions and learn about how best to leverage them

Results



of Phase 2 projects had a specific focus on nutrition-sensitive pathways. They achieved results by changing behaviours and diets and scaling up the production and consumption of nutritious foods

Consumers are accessing more nutritious foods: for example,

- double-fortified salt reached **50 million** Indian consumers by mid-2018
- more than **140,000** litres of vitamin A-fortified oil reached **500,000** consumers in Tanzania

Education is key to improved nutrition: for example,

- more than **45,000** individuals, including village-level health workers and mothers of under-twos, received education on pulse-containing foods in Ethiopia

Some 805 million people worldwide suffer from undernutrition, while a further 2 billion live with critical micronutrient deficiencies.¹ Most people affected by undernutrition and malnutrition live in low- and middle-income countries, where the greatest concerns are for the mental and physical development of infants and the elevated risk to women, girls, and adolescents. Nearly half of all deaths among children under the age of 5 are linked to undernutrition.² At the same time, rates of childhood overweight and obesity are rising.

Agriculture is central to human nutrition through its direct contributions to household food consumption, income generation, and women's empowerment. There is growing recognition that agricultural development is a strong entry point for efforts to improve nutrition — among the UN

Sustainable Development Goals (SDGs) adopted by global leaders, SDG 2 aims to “end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.”

However, pathways between agricultural interventions and nutritional outcomes are complex, with economic, social, and gender dimensions. Research to date has shown that improved nutritional outcomes not only occur as a result of food intake or increased agricultural production, but also are influenced by water quality, care practices, disease burdens, and sanitation and health services. In each society, a range of underlying social, economic, and political processes — including the status of women — affects how resources are shared and used. This in turn shapes the more proximate causes of malnutrition as illustrated in the UNICEF framework on the underpinnings of malnutrition.³

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▲
Asha is cooking lunch using some double-fortified salt she received through the Public Distribution System, Jharkhand, India.

Approaches

The Canadian International Food Security Research Fund (CIFSRF) integrates agricultural production and nutrition across its program objectives and strategy. From the beginning, it has promoted nutrition-based innovations alongside efforts to sustainably enhance food production by smallholder farmers and increase their economic returns. To some degree all projects addressed nutrition, although some focused more explicitly on nutrition interventions. While these projects differ, this section analyzes the strategies and pathways used to achieve results related to improving the quality of the diet to improve nutrition.

At the program level

Phase 2 aimed to scale up successful nutrition-sensitive agricultural interventions based on the proof of concept and evidence generated during Phase 1. Among Phase 2 goals were the increased use and scale-up of environmentally sustainable food security and nutrition innovations to benefit subsistence farmers (particularly women) and the development of more informed, gender-responsive, environmentally sustainable, and better-developed public policies and programming related to food security and nutrition in developing countries.

Thirteen of 21 Phase 1 projects identified nutrition as a main project objective and tested a range of interventions, including home gardening and homestead food production, aquaculture, livestock rearing, cropping improvements and diversification, and food fortification. In Phase 2, the program-level questions shifted from exploring which foods were most nutritious or which farming methods were most sustainably productive to identifying the most successful pathways in reaching the greatest number of people with nutritious foods. Projects therefore focused on bringing successful models and interventions to scale through expansion, replication, or adaptation in a cost-effective manner.

Projects worked for greater inclusion of women to enhance their decision-making control within households, which improves nutrition and other health outcomes in families.

Within projects

While each of CIFSRF's Phase 2 projects contributed to food security, 10 of the 18 projects featured a strong focus on nutrition, as shown in Table 2. Most projects used a combination of three key strategies to address nutrition:

- dietary diversity and more nutritious crops
- food fortification and value-added food processing
- nutrition education and promotion

Nutrition education was a common factor across the 10 projects. CIFSRF's cross-cutting focus on addressing the needs of women farmers (see section 4) is consistent with the understanding of development agencies that have highlighted the crucial role that women's status plays in addressing malnutrition. Projects worked for greater inclusion of women at all stages of the production and value chains to improve their decision-making control within households, which has been shown to play a significant role in improving nutrition and other health outcomes.

Results

According to an analysis of Phase 2 projects conducted by the Overseas Development Institute (ODI) in mid-2018, the 10 projects with a specific focus on nutrition-sensitive pathways successfully changed behaviours and diets and scaled up the production and consumption of nutritious foods.⁴ As Phase 2 projects largely focused on scaling up interventions already identified through earlier research as effective in improving nutritional outcomes, not all captured data on changes in nutritional status of participants as a result of their changing diets. Examples of results can be seen in terms of increased production, distribution, and consumption of nutritious foods, captured in Table 2. The results are noted where changes in health were directly monitored. This is consistent for agriculture/food security projects whereby they progress along a pathway of change towards the ultimate goal of improved nutritional status.

As Phase 2 focused on how to reach more people, results are also seen in the innovative pathways through which projects scaled up nutrition-sensitive agricultural innovations. These ranged from nurturing entrepreneurial producer groups and enhanced value chains to expanding markets for nutritious foods, working with state procurement and agricultural extension services, and institutionalizing their production, distribution, and consumption. A list of policy outcomes influenced by CIFSRF is provided on the policy map.

Results can also be observed in how women's status was enhanced through project activities. In addition to tapping their traditional role as mothers and wives to improve nutrition, projects increased community recognition of their vital role as food producers, businesswomen, decision makers, and research partners.

Increasing dietary diversity and introducing more nutritious foods

Six of the 10 projects had a significant focus on dietary diversity, either by broadening the range of nutritious foods being produced and consumed or by scaling up an individual crop or food. Most supported the introduction or intensification of vegetable, grain, or pulse crops, while research in Bolivia and Cambodia also promoted the addition of fish or poultry to diets as an important source of protein. Four of these projects focused primarily on a nutritious food crop or type (fish in Bolivia, improved potato varieties in Colombia, pulses in Ethiopia, and small millets in India). Research in Cambodia and West Africa focused on diversifying family diets, with the latter focusing on four varieties of overlooked indigenous vegetables. Four of these six projects included a secondary focus on some form of nutrition-relevant food processing or value addition. Four projects also demonstrated unique opportunities through school-based programs such as school meals, gardening, and nutrition education to achieve nutrition and health outcomes while also supporting local food production systems to ensure the availability of nutritious foods.



Results of scaling up included some impressive gains in production and consumption levels and increases in dietary diversity scores in participating households. One example for this strategy comes from Bolivia, where fish is not widely consumed and where low-income families are deprived of an important source of protein. The Amazon Fish for Food project successfully worked with small-scale farmers and fishers to increase incomes and improve diets through household-level fishing and fish-farming enterprises. Phase 2 focused on scaling up; research explored initiatives with the greatest promise to improve household food security. These included developing fisheries led by indigenous communities for a large, invasive freshwater species known as paiche, and expanding small-scale pond farming of two varieties of the native fish species pacú, led primarily by women.

© Steve Sugrim



Unrefined sunflower oil fortified with vitamin A is sold in a rural market in Babati, Tanzania, in order to reach women and children experiencing high vitamin A deficiency.

Canadian and Bolivian research partners provided a range of technical and commercial support, including in participatory market development, to optimize value chains related to fish, strengthening fisheries management and family-based aquaculture, and assessing the sustainability of the fish resources. They provided micro-financing, helped develop supportive networks and collaborative platforms, and expanded these practices to other locations.

During the project timeframe, the productivity of fish farming increased six-fold in five municipalities. Marketing events, including fairs in major cities and rural communities, helped build an appetite for fish by introducing consumers to novel recipes and the nutritional benefits of fish consumption. Market surveys showed a national gain of 20.8% in paiche consumption and 37.9% in pacú consumption between 2015 and 2017. Along with a 240% increase in incomes over two years, fish-farming families increased their own fish consumption by 12 kg per family per year. Women are among the main beneficiaries of aquaculture; many increased their incomes and gained decision-making power in their families and in producer associations. One indication of the project's success is that many fish farmers today proudly call themselves businesswomen.

Food fortification and value-added production

Industrialized countries have been fortifying foods for more than 80 years as a means of addressing micronutrient deficiencies due to inadequate intake of fruits, vegetables, animal-source products, and other micronutrient-rich foods.

Food fortification can effectively target specific deficiencies by increasing the micronutrient content of staples and condiments consumed by large segments of the population, including vulnerable groups such as women and children.⁵ Besides food fortification, value addition can be achieved through specific processing or storage methods that enhance the nutritional quality of diets.



Results of scaling up included impressive gains in production and consumption levels and increases in dietary diversity scores.

Food fortification and value addition was the central focus of four research efforts in particular: the production and promotion of probiotic fermented foods in East Africa, double-fortified salt in India, vitamin A–fortified sunflower oil in Tanzania, and the local manufacture and distribution of complementary foods for young children in Vietnam.

These projects tested three main strategies for scaling up:

- mass fortification of publicly distributed staples (yogurt, salt, and sunflower oil)
- processing and commercialization of fortified complementary foods and development of a local commercial supply chain
- processing pulses or millets to add nutritional value and convenience

All involved a high degree of collaboration with local companies and producer cooperatives ranging in size from micro-enterprises to medium-sized equipment suppliers and processors. They also entailed extensive engagement with government authorities to ensure products met minimum equipment, sanitation, and other food safety standards.

The public distribution of salt fortified with iodine and iron in India achieved a massive scale-up. This fortified staple addresses two key micronutrient deficiencies of particular concern among low-income children and women of child-bearing age. Using a premix formulation developed at the University of Toronto, the project worked with the public distribution system in Uttar Pradesh state and local manufacturer JVS Foods to reach 24 million people. The states of Madhya Pradesh and Jharkhand have since procured the double-fortified salt (DFS) formulation for distribution through

their public systems. As of mid-2018, an estimated 50 million people were consuming DFS. The St. John's Research Institute of Bangalore is studying the effectiveness of the intervention in improving the iron status of the product's consumers in Uttar Pradesh.

In Vietnam, Ryerson University and Vietnam's National Institute of Nutrition (NIN) took a different approach to scaling up production and consumption of nutrient-rich complementary foods, targeting young mothers and their infants. They worked to develop a local value chain to produce a range of fortified, easy-to-use meals and marketed them along with

nutritional education to mothers through Little Sun nutrition counselling centres and at preschools. Research addressed food insecurity and chronic malnutrition among children in three northern provinces located in remote mountainous areas. In collaboration with the private sector, the project procured crops from women farmers to produce the fortified food in a small-scale food processing plant to be distributed through local vendors. The two main products, branded as ECOSUN, are an instant rice porridge fortified with iron and zinc, and vegetable powders fortified with calcium, magnesium, manganese, zinc, and vitamin D.

Scaling up nutrient-rich potato production through rural entrepreneurship

In Colombia, a research partnership between McGill University and Universidad Nacional de Colombia demonstrated the integration of all three pathways to scale up the production and consumption of more nutritious foods.

During Phase 1 research, the team developed three new yellow potato varieties that are twice as resistant to late blight disease and contain 19% more iron and 17% more zinc than local varieties. Since potatoes are a staple food, these mineral-rich varieties offer a locally sustainable way to combat micronutrient deficiencies.

In Phase 2, the team scaled up cultivation and consumption by fostering rural entrepreneurship and the development of local value chains to produce and market the potatoes and related food products. To address the lack of reliable seed potatoes in local markets, farmer groups were supported to produce and market certifiable seed potato, a key factor to sustain scale-up. As of March 2018, the new varieties accounted for 16% of the total cultivated area of yellow potatoes, and improved potato varieties were available to 6.5 million Colombians.

To improve household nutrition, the team promoted home gardening, provided nutritional counselling linked to micronutrient supplements, and empowered women through local savings groups. A total of 160 families were involved in the *Shagras para la Vida* program, which promoted the recovery of a variety of traditional foods, along with healthy eating and nutrition habits. Among participating families, the number of households classified as food secure increased from 19% to 59%, while the proportion with adequate diet diversity increased from 17% to 52%.

By advising a national campaign called *La papa tiene lo suyo*, the project also contributed to the national promotion and consumption of more nutritious potatoes. A wide cross-section of the Colombian population was reached through mass media, including radio and television.

As of mid-2018, 22,248 children under the age of 2 have been reached through family nutrition counselling sessions. A follow-up study with 995 mother–child pairs found a decrease in malnutrition rates and a dramatic decline in anemia rates among children, which dropped from 61% to 16.1%. (Further analysis is needed, and the small sample size merits caution in interpretation.) Some improvements were also seen in rates of breastfeeding in children's first year.

To sustain the effort, a 10-year public–private partnership has been formalized between NIN and a local female-run small-scale business for ECOSUN food production. The production facility, which is ISO 22000 compliant, ensuring product safety, aims to produce 100 tons of fortified instant porridge and 2 million vegetable packets annually.

Nutrition education and promotion

Food production and income gains will not improve nutrition outcomes if there is no understanding of how to properly balance nutritious diets.⁶ Therefore, all of the 10 CIFSRF projects with a specific focus on nutrition included an education component.

Nutrition education typically involves teaching people about healthy diets and food preparation, child feeding, safe drinking water, and hygiene. Four projects targeted care providers, typically mothers, for education on best practices in child feeding, health, and sanitation. In addition to the research in Vietnam discussed above, these included the projects on homestead food production in Cambodia, more nutritious potatoes in Colombia, and pulse crops in Ethiopia. The small millet project in India, which included value-added processing, also trained food processors and vendors on hygiene in commercial food preparation and storage.



Food production and income gains will not improve nutrition outcomes if there is no understanding of how to properly balance nutritious diets.

All projects engaged in some form of marketing and promotion to raise public awareness of the health benefits of the nutritional products or innovations they were scaling up. Amazon Fish for Food held a series of urban and rural food fairs that used cooking demonstrations and sample products to increase demand for fish. A number of projects also used radio and social media to broadcast their nutrition messages more widely.

Best practices

Perhaps most importantly, CIFSRF's nine years of participatory research on food security validated what may seem obvious — that with the right support, integrating an intentional focus on nutrition within agricultural interventions can improve nutritional outcomes. CIFSRF projects pursued various pathways to achieve these outcomes, but a number of cross-cutting lessons emerged.

Nutrition education plays a vital role in linking agricultural development to nutritional outcomes

A defining feature of CIFSRF's nutrition-focused research was the educational component. Experience affirms what earlier studies have shown — that nutrition education plays an important role in prompting the social and behavioural change necessary to improve nutrition outcomes.

An analysis by ODI found the education and communication components of CIFSRF projects were highly relevant, especially in addressing micronutrient deficiencies that have less visible health effects than undernutrition (such as wasting or stunting). Education is also important to ensure that the underlying causes of malnutrition are considered along with nutritious foods and diet quality.

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◀ Ingrid Flores serves her fish soup at her restaurant 'Buen Gusto'. Riberalta, Bolivia.

CIFSRF research also validated a number of strategies for delivering nutritional education, including government health extension services, reaching care providers in preschool centres, promotional efforts such as food fairs and recipe demonstrations, and wider diffusion through radio broadcasts and social media.

Nutrition education sessions also provided important feedback for research teams. In Ethiopia, researchers learned that families had a limited ability to act on the nutrition counselling they received because of factors beyond their control, such as access to and

availability of food or lack of control over decision making. Awareness of these factors can help project teams fine-tune strategies that empower women to make the right choices to improve food and nutrition security for themselves and their families.

As many governments are interested in taking advantage of schools as platforms for improving nutritional outcomes, encouraging consumption of fresh healthy foods, and procuring food from local small-scale farmers, lessons from CIFSRF projects offer relevant insights.

Engagement with policymakers and the private sector is particularly important for value-added food fortification pathways

Policy influence was a central objective of all CIFSRF projects. Several teams successfully informed food and nutrition security policies at local, regional, and national levels. In Cambodia, researchers advised the government on two consecutive national strategies for food security and nutrition (2014–2018 and 2019–2023). This influence results in part from the competence of teams and their strong reputations and close connections with policymakers.

To achieve their food fortification goals, projects such as double-fortified salt in India and fortified crude sunflower oil in Tanzania had to break ground in identifying and supporting local businesses as the backbone of new supply and value chains. At the same time, the health and safety standards that apply to the creation and marketing of new fortified foods necessitated close collaboration with authorities in ministries responsible for food safety. This engagement was a boon for research uptake, but also a source of delays and additional costs. In Tanzania, for example, local producers of vitamin A-enriched oil had to purchase stainless steel mixing tanks that exceeded the standards of competitors to expedite approvals.

As highlighted in section 6, engagements with the private sector and policymakers are ultimately worthwhile, but their demand on time should be recognized at the early stages of research design.

Gender roles are an important consideration for designing nutrition-sensitive agricultural interventions, and we still have much to learn about how to leverage them

CIFSRF's cross-cutting focus on the needs of women smallholders positively impacted families' nutritional outcomes. This is consistent with conceptual frameworks that have identified women's status as an important determinant of household nutrition and health. Nutrition education largely engaged women in their traditional roles as care providers. At the same time, other research dimensions (as seen in section 4) validated and empowered women as farmers, income earners, entrepreneurs, research collaborators, and decision makers.

Some projects deliberately targeted men for participation in project activities that encouraged the sharing of caregiving responsibilities and decision making. In Cambodia, although some men came to better understand and appreciate the value of women's contributions, men's participation was inconsistent (in part because of the pressures of outward migration). In Colombia there was an appreciable improvement in women's reported role in household decision making.

A lesson for researchers and development practitioners is to include a gender expert or focal point to ensure that interventions are gender and nutrition sensitive. For example, while vitamin A is particularly important for pregnant and lactating women, it is men in Tanzania who allocate household spending. Following a gender capacity development training, the project placed renewed emphasis on engaging and sensitizing men to the importance of fortified foods.

Qualitative evidence suggests that CIFSRF's attention to women's needs and status correlates strongly with improved nutrition, but much of this impact will need to be quantified.

Table 2: Key CIFS RF Phase 2 contributions to nutrition strategies

Country/research focus	Main nutrition strategies	Main contributions to improved nutrition
Bolivia: Fish for Food	Dietary diversity and more nutritious crops	Farmed fish production rose six-fold
	Food fortification and value-added food processing	Demand for fish rose by 32% in urban areas
	Nutrition education	Nationwide consumption of paiche and pacú/tambaqui grew by 21% and 38% respectively between 2015 and 2017
Cambodia: Enhanced productivity and diversity of homestead gardens	Dietary diversity and more nutritious crops	17,500 individuals improved and diversified their diets
	Nutrition education	Home gardening increased by 57% in targeted households and the variety of vegetables more than doubled
		Women and children in gardening households demonstrated an increased intake of zinc, thiamine, riboflavin, and vitamin A
Colombia: Nutritious and higher-yielding potatoes	Dietary diversity and more nutritious crops	Improved potato varieties became available to more than 6.5 million Colombian consumers
	Food fortification and value-added food processing	New varieties of yellow potatoes are now grown on 16% of land cultivated with traditional yellow potatoes
	Nutrition education	
East Africa: Fermented food for life	Food fortification and value-added food processing	Probiotic yogurt was consumed by more than 200,000 people
	Nutrition education	More than 260 production units (56% women-owned) are producing over 45,000 litres of probiotic yogurt/week
Ethiopia: Scaling up of pulse innovations	Dietary diversity and more nutritious crops	Nutrition education reached 23,059 individuals
	Food fortification and value-added food processing	More than 35,000 consumers used foods containing pulses, which boosted protein consumption
	Nutrition education	By the project's end, children increased their consumption of legumes, nuts, and seeds by 27%, of vitamin A-rich fruits and vegetables by 24%, of dairy products by 7%, and of other fruits and vegetables by 12%

Table 2 (cont.): Key CIFSRF Phase 2 contributions to nutrition strategies

Country/research focus	Main nutrition strategies	Main contributions to improved nutrition
India: Double-fortified salt	Food fortification and value-added food processing Nutrition education	Double-fortified salt (DFS) reached 50 million consumers by mid-2018 More than 10,000 village-level health workers were trained on the nutritional benefits of DFS
India: Small millets	Dietary diversity and more nutritious crops Food fortification and value-added food processing Nutrition education	1,015 tons of bulk small millets and 210 tons of value-added products have reached 285,500 consumers
Tanzania: Vitamin A–fortified sunflower oil	Food fortification and value-added food processing Nutrition education	More than 140,000 litres of vitamin A–fortified oil produced and sold, reaching 500,000 consumers
Vietnam: Processing complementary foods	Food fortification and value-added food processing Nutrition education	Mothers of 22,248 under-twos received nutrition counselling and complementary foods 20,000 rural women have been reached through individual and family nutrition counselling and training and are using the fortified complementary foods for their children Preliminary results point to a decline in undernutrition and anemia in children and an increase in breastfeeding in infants' first year
West Africa: Indigenous vegetables and micro-dose fertilization	Dietary diversity and more nutritious crops Food fortification and value-added food processing Nutrition education	337,931 farmers (51% women) tested methods to increase production and consumption of nutritious indigenous vegetables 80,000 hectares are now being cultivated with indigenous vegetables — a 768% increase in Nigeria and a 161% increase in Benin

Source: Abridged and updated from Keats, S., Lowe, A., Shaxson, L., and Wiggins, S. 2018. Understanding the CIFSRF Phase 2 portfolio's contribution to improved nutrition. London: Overseas Development Institute. <http://hdl.handle.net/10625/57233>.



▲
Enjoying fresh
yogurt prepared
using freeze-dried
probiotic bacteria,
Nakaseke District,
Uganda.

- 1 FAO, WFP, and IFAD. 2014. The State of Food Insecurity in the World 2014. Rome: Food and Agriculture Organization of the United Nations.
- 2 WHO. 2018. Malnutrition Fact Sheet. <http://www.who.int/news-room/fact-sheets/detail/malnutrition>.
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- 4 Keats, S., Lowe, A., Shaxson, L., and Wiggins, S. 2018. Understanding the CIFSRF Phase 2 portfolio's contribution to improved nutrition. London: Overseas Development Institute. <http://hdl.handle.net/10625/57233>.
- 5 FAO. 2017. Nutrition-sensitive agriculture and food systems in practice. Rome: Food and Agriculture Organization of the United Nations.
- 6 UNICEF. 2011. Infant and Young Child Feeding: Programming Guide. New York: United Nations Children's Fund.

3

Enhancing smallholder incomes for resilience and food security





Approaches

Projects used three approaches to increase farmer incomes:

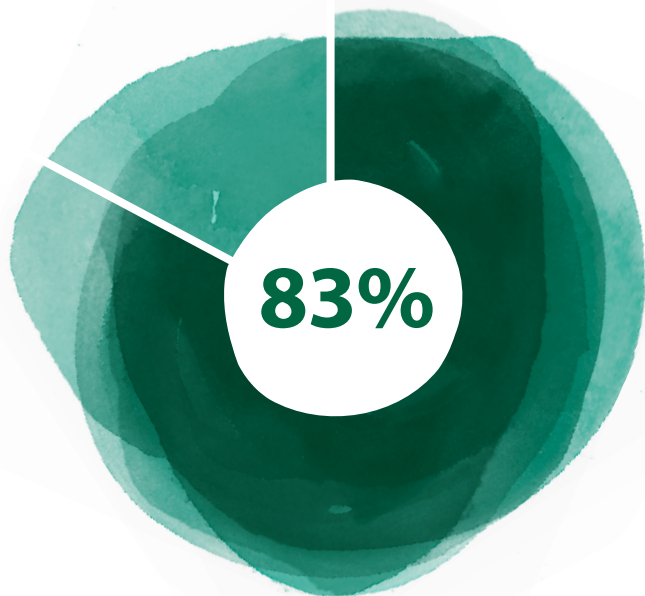
- promoting innovations that increased production and enabling sales of excess crops and fish/poultry
- reducing crop and livestock losses
- promoting value-added food product processing using produce from smallholders and/or the labour of local small-scale manufacturers



Best practices

- Ensure that income-generating activities are relevant, accessible, and well supported
- Remember that not all business gains are monetary
- Recognize that policy influence is instrumental and essential when income gains depended on innovation
- Understand that sustaining gains depends to some extent on the continued functioning of public and private services
- Acknowledge that even modest gains in income contribute to households' adaptive capacity

Results



of CIFSRF Phase 2 projects saw appreciable income gains (mainly for low-income producers, more than half of them women)

Food processing and the creation of value-added products also boosted incomes for vendors, processors, and the small-scale manufacturers and suppliers who equipped them: for example,

- the price of fish skins for tanning in Bolivia doubled from **CA\$3.42/kg** to **CA\$7.60/kg**

Most income gains were from sales of crops or fish resulting from increased production that were sold into existing markets: for example,

- among fish-farming families in Bolivia, incomes more than doubled, from **CA\$10,114** to **CA\$25,046** /year
- weekly incomes from farming indigenous vegetables in Nigeria tripled during peak season, from **CA\$900** to **CA\$2,700** /week

- farmers growing new potato varieties in Colombia increased their income by **18%** (from US\$28,196/hectare to US\$33,274/hectare)

Projects achieved income gains by reducing crop and livestock losses caused by disease or spoilage: for example,

- in Tanzania, mango fruit drop was reduced by **40%**

While the Canadian International Food Security Research Fund (CIFSRF) did not have standalone objectives to improve the incomes of smallholder farmers, income as a component of food security was integrated across CIFSRF's performance framework. Food security depends on more than the availability of food: it must also be accessible in local markets, and people need enough income to buy what they cannot produce.¹ As incomes rise, people tend to eat fewer starchy foods and consume more meat, fish, dairy, fruit, vegetables, oils, and sugar. As a result, diets become more diverse, and potentially more nutritious.

While rising income in some middle- and high-income countries has been associated with greater consumption of unhealthy processed foods, these risks are generally lower among rural households on very low incomes.² Poor rural households make up an estimated two-thirds of those who earn less than

US\$1.25 per day.³ Staples such as grains, roots, and tubers that sustain these households are harvested at most twice a year. During the "hunger" season between harvests, cash earnings enable families to buy food rather than cut portions or skip meals. Increased earnings can thus help stabilize food security among impoverished rural households.

Increasing women's income and control over household spending is particularly important for improving household diets because women are more likely than men to invest in their children's health, nutrition, and education.⁴ Additional income has added benefits for poor households, such as sending children to secondary school. This in turn has been linked to improved child nutrition⁵ because of a combination of better education about diet, hygiene, and child care; women having more earning potential; and the resulting increased status and agency of educated young women.

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◀ Luz Dary Gelpud Rojas of the Asaais Association of farmers, checking the health of the flowering of potato improved cultivars, Pasto, Colombia.

Approaches

At the program level

While Phase 1 of CIFSRF focused on testing a broad range of food security innovations, Phase 2 tested and scaled up practical innovations that had shown promise for increasing food production, raising incomes for farming families, and/or improving nutrition.

Increasing income for smallholder farmers was not a standalone objective, but as a component of food security it was an inevitable pursuit across CIFSRF's performance framework. Incomes, productivity, and nutrition are intrinsic to CIFSRF's ultimate goal of increasing environmentally sustainable food security for the most vulnerable.

Within projects

Although CIFSRF-funded projects did not set out to raise incomes per se, an analysis conducted by the Overseas Development Institute⁶ found that all but three of the 18 projects supported in Phase 2 saw appreciable income gains for some or all project participants. These income gains tended to be part of a broader research effort targeting food security.

Projects increased participant incomes in three main ways:

- promoting innovations that increased production and enabled sales of excess crops and fish/poultry
- reducing crop and livestock losses
- promoting the processing of value-added food products using produce from smallholders and/or the labour of local small-scale manufacturers

Women's cash earnings helped to validate their role in agriculture and gave them a new degree of control over spending.

Results

Incomes were raised in 83% of Phase 2 projects. Most of those who benefited were low-income smallholders such as farmers, livestock keepers, and fishers (approximately half were women).

Others who increased their income worked in supply, distribution, or value chains associated with crops or food products. They included

- storekeepers, dealers, and traders supplying inputs to producers
- processors of foodstuffs
- local manufacturers who provided equipment for processors or craftspeople
- retailers who sold the resulting produce and related products
- farm labourers contracted as extra hands by primary producers as they increased their output

The amounts of additional income generated varied considerably, though for most the gains were modest and not enough to lift households out of poverty. Yet even the small amounts of cash earned, combined with non-cash benefits such as improved nutrition and more resilient production, made valuable contributions to households.

Women's cash earnings helped to validate their role in agriculture and in some cases gave them a new degree of control over spending and input into community and household decisions. Giving women more control over cash income will also likely lead to more being spent on nutrition for the household. Moreover, in terms of food security, even a small cash income in the lean season can make a significant difference between malnourishment and being able to afford low-cost additions to the diet, such as eggs and vegetables.

Increases in agricultural production

Nine projects generated cash incomes by increasing agricultural production (see examples of results in Table 3), and in five projects the additional produce was mainly for sale. In these cases, increased earnings were attributed to raising the productivity and production of crops and fish or poultry. The non-cash benefits of sustainably increasing food production, and often the diversity and nutritional value of foods, were of even greater significance.



In Bolivia, for example, many poor households overlook fish as an important source of protein. The Amazon Fish for Food project promoted family fish farms and commercial fisheries of paiche, a large and locally invasive species. Incomes more than doubled among fish-farming families, from CA\$10,114 to CA\$25,046 per year. The productivity of fish farming increased six-fold in core research areas, and the catch from wild fisheries doubled (see Table 3).

In most projects, income was earned from products that were either already being grown or were similar to something already produced, such as new varieties of an existing crop or the addition of a new crop to the field. In six projects, research focused on raising production across a range of crops and/or fish. Sales were largely made in existing markets through established channels. For example, research in Nepal's challenging mountainous terrain aimed to scale up the use of sustainable agriculture kits (earlier research

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▲ Nadia Assouma buys indigenous vegetable amaranth from the women vegetable marketers, Arzeke Urban Market, Parakou, Benin.

had shown that these kits sustainably increase the productivity of terrace farming). The kits, which can increase annual net farm income by up to CA\$250 per household, provide a range of seeds, tools, and guidance material that enables farmers to capitalize on underused space. They also provide a range of tools that reduce the physical effort required to farm this challenging terrain, a great benefit to women, who make up 79% of kit users.

A few projects focused their efforts on getting the most out of a single crop or using it to boost yields of other crops. In Ethiopia, researchers scaled up the production and consumption of nutritious pulses by double cropping with chickpeas.

Some projects improved supply chains. The research team in Nepal worked with an input supply company and their agro-dealer distribution networks to create and distribute supplies of inputs, tools, and seed to terrace farmers.

Reducing losses

Four projects raised incomes by reducing crop and livestock losses. These projects were characterized by an intense focus on a technical innovation to mitigate or prevent disease or reduce pre- and post-harvest losses.

The global demand for coconut products has boomed in recent years as their health benefits become better known. The coconut water industry alone is estimated at over US\$2 billion today and is expected to nearly double by 2019.⁷ But in recent decades, lethal yellowing disease has devastated production in several countries. In Côte d'Ivoire, the disease puts the livelihoods of millions of small-scale growers at risk. Sporometrics Inc., a Canadian microbiology testing company, worked with Ghanaian researchers to develop a new technology for in-field detection of the bacteria responsible for the disease. Working with local farmers, extension workers, policymakers, and private sector suppliers,



The non-cash benefits of sustainably increasing food production, and often the diversity and nutritional value of foods, were of even greater significance.

the team developed a disease management plan and a three-year rehabilitation plan to tackle the spread of the disease and help growers find alternative sources of income. The project also enabled women coconut farmers, who are extremely vulnerable to the impacts of the disease, to organize among themselves for the first time. In addition to hosting fairs to sell their coconut foods and crafts, women's groups were formed in six villages and are currently diversifying into cassava.

India produces 40% of the world's mangoes, but pre- and post-harvest losses have been estimated at 2 trillion rupees (approximately CA\$36 billion). During Phase 1 research, Canadian, Sri Lankan, and Indian researchers had excellent results field testing a range of preservative sprays, waxes, and packaging based on a nanotech-engineered formulation of hexanal, a natural plant extract. In Phase 2 research, the team extended their testing to countries in Africa and the Caribbean and to a wider range of fruit. In India, the applications increased the shelf life of mangoes by 14 to 21 days under ambient storage conditions. In India and Sri Lanka, mango farmers earned an estimated CA\$200/acre from the increase in yield due to higher fruit retention, and they can earn an additional CA\$280/acre by delaying ripening by two weeks so the fruit reaches markets when prices are higher.

Two projects that focused on improved livestock vaccines — one focused on contagious bovine pleuropneumonia (CBPP); the other on combination vaccines for widespread livestock diseases that threaten small herders' livelihoods — may yet yield large income gains for herders, once field testing and registration are complete and the vaccines become widely available. Nearly 1 billion people living on less than US\$2 a day in

South Asia and sub-Saharan Africa keep livestock. In sub-Saharan Africa, the average gross value of livestock production in 2012 to 2014 was around US\$36 billion, according to UN Food and Agriculture Organization estimates, so that disease losses of 20% would be worth US\$9 billion. If the vaccines being developed were able to reduce disease losses by just 10%, the gain to livestock keepers across the continent would thus potentially be US\$900 million. Furthermore, a 2009 analysis of 92 developing country case studies showed that, in pastoralist families, livestock accounted for more than half of household income.⁸

If the vaccines being developed were able to reduce disease losses by just 10%, the gain to livestock keepers across the continent would potentially be US\$900 million.

Boosting incomes and nutrition by reviving indigenous vegetables in West Africa

Indigenous African vegetables have been largely ignored as a source of food security despite their accessibility to some of the lowest-income families. Earlier research in Nigeria showed some varieties of leafy indigenous greens to be rich in vitamins and nutrients, and a potential source of income for smallholders and vendors. A partnership between universities in Canada, Benin, and Nigeria tested more efficient growing methods and worked with a range of producers, processors, and marketing partners to develop new techniques and value chains to make these nutritious foods more widely available.

Efforts focused on four indigenous vegetables: African eggplant, fluted pumpkin, slender amaranth, and African basil. With improved irrigation, quality-controlled seed, and the use of targeted microdoses of fertilizer, the land devoted to indigenous vegetable production increased by 161% in Benin and nearly 800% in Nigeria. In all, 338,000 farmers were involved, just over half of them women.

More than 28,400 vegetable marketers also benefited. Revenues increased by nearly 120% in Nigeria and by over 90% in Benin over the project's 36 months.

Preserved and packaged vegetables extended their reach even further and created spin-off opportunities for food processors, suppliers, and vendors. The team developed low-cost sun dryers and charcoal-powered ovens to dry and store leaves for up to 12 months. Frozen vegetable products were also created and are being marketed through more than 600 distribution points. Polyphenol extracts from the vegetables were used to fortify a range of foods, including pineapple juice, breads, and pastries that are showing promise in test marketing. Favourable terms on microcredit loans encouraged the participation of small producers and processors in value chains.

Beyond its contributions to incomes and nutrition, research is helping to re-establish an important part of Africa's food heritage. Progress can be seen in uptake within schools, such as on-campus vegetable sales at universities in Benin and Nigeria, and even the involvement of 600 inmates who are now producing their own vegetables at Nigeria's Ilesha Prison.

Valued-added processing

Two projects focused primarily on scaling up the processing of nutritious foods into novel products that would enhance their appeal and consumption. These processed foods constituted new products, mainly sold into existing markets.

In East Africa, collaboration between Canadian, Dutch, Kenyan, Tanzanian, and Ugandan researchers and social marketers resulted in the scaling up of a production and distribution model that has seen more than 200,000 consumers purchase probiotic yogurt, boosting employment for women's producer groups and local vendors. The project overcame a key barrier to local production by incorporating a new technology for freeze-dried probiotic bacteria with a two-year shelf life. More than 260 production units in Kenya, Tanzania, and Uganda are producing over 45,000 litres of probiotic yogurt per week. In Tanzania and Uganda, 63% of the production units are owned by women, and 60% of the 945 people involved in production, distribution, and marketing are women. The net profit of selling 1 litre of probiotic yogurt is at least three times the net profit of selling 1 litre of fresh milk.



Indian and Canadian researchers partnered to scale up production and consumption of small millets, based on earlier research that showed its nutritional and livelihood benefits. They gave local industry a leg up by providing dehullers, which greatly reduce the time and effort needed to process this tiny grain. Incubation support was also provided to 61 micro, small, and medium-sized food enterprises. A range of value-added products was created and marketed, including 14 therapeutic foods and 42 small millet-based foods. Over 150 small millet vendors were trained in food hygiene practices; roughly half went on to register formally with Food Safety and Standards Authority of India. In all, 210 tons of value-added food products reached 278,000 new consumers.



▲ Javier Sandovar, the president of the ASPYC Association of Fisherman. Abasto Market (The Indigenous Fisherman's Market). Riberalta, Bolivia.

Best practices

Most income-generating activities were effective because they were relevant, accessible, and well supported

Most activities that aimed to generate income did so, largely because they were relevant and accessible to the low-income households that were targeted. The nine projects that raised production involved incremental changes to the production of known crops and fish that generally did not require major changes to the farming system or large capital injections and that could be readily sold into existing markets. They largely drew on the existing resources of participating households, especially their skills and experience as farmers.

Where new tools and techniques were promoted, or where value-added processing demanded new capacity and investment in equipment and marketing, multidisciplinary teams provided a range of support. Sometimes they tapped private sector or civil society partners to accompany various actors in the value, supply, and distribution chains. Micro-credit facilities helped producers, vendors, and processors invest, while marketing specialists helped reach more consumers.

Policy influence was often instrumental and was essential when income gains depended on innovation

Policy engagement played an important role in several projects. In Bolivia, for example, the project team worked with government to change the legal framework for collective management of river fisheries and worked with local health authorities to improve hygiene and food handling among vendors to gain wider consumer acceptance. In India, government authorities were lobbied to include small millets in state procurement programs.

Where research involved significantly novel innovations, such as livestock vaccines, policy engagement was essential and in some cases required extensive time and effort to obtain regulatory approvals.

Even modest gains in income contribute to a household's adaptive capacity

As rural economic and social systems evolve in developing countries, farm household food security is increasingly dependent on non-farm earnings. In Nepal, for example, many communities have high rates of male migration, and remittances play an important role in sustaining their families. But not all village households have access to the new sources of income; many will continue to depend on their farms for some time. For these people, in many cases female heads of household, CIFSRF innovations can be far from marginal. Increases in income, however small, make important contributions to spending on nutrition, health, and education. Many rural households depend on multiple, though small, income streams. Sustainable systems are characterized by diversity and the ability to change with circumstances. Those CIFSRF activities that boost cash incomes contribute to the adaptive capacity and hence sustainability of ecosystems, communities, and households.

Not all business gains are monetary

Some producers selling items such as fish, vegetables, or millet-based snacks reported gains other than cash earnings. For example, they spoke about their satisfaction in selling healthier items to their neighbours and fellow villagers and in raising horticulture or livestock in more environmentally sustainable ways, their pride in improved capacity and knowledge of food preparation or running small businesses, and their improved standing in households or communities.

The women shopkeepers who excelled in promoting and selling vitamin A-fortified oil in Tanzania, for instance, were motivated to be champions of fortified oil not only to improve their own profits, but also to help improve the health of their customers' families.

Sustaining gains depends to some extent on the continued functioning of public and private services

The income gains seen in the projects are likely to be sustained, provided that the ratio of benefits to costs remains advantageous for farmers and provided that small-scale producers and processors strive to improve their operations. The latter point is generic to agriculture and primary production the world

over: costs of production in almost all branches of agriculture have fallen significantly for many decades now, as technical advances and more effective management have been deployed. This also requires that smallholders have access to information, capital, and technical advice to regularly improve their operations. In the long term, sustaining gains depends on developing support services for both public and private agriculture.

Table 3: Key CIFS RF Phase 2 contributions to increasing incomes

Country/research focus	Who benefited	Main contributions to improved income
Bolivia: Fish for Food	1,757 families involved in fish production in target and neighbouring municipalities (compared to 937 in 2015) 742 tons/year of the introduced paiche fish being exploited by 772 fishers (379 indigenous) and 66 sellers or retailers (up from 304 fishers and 520 tons/year in 2011 and 2014 respectively)	<p>The Amazon Fish for Food project promoted both fish farms and better-managed commercial fisheries of paiche, a large, locally invasive species. Incomes more than doubled among fish-farming families (from CA\$10,114–\$25,046/year)</p> <p>The productivity of fish farming increased six-fold in core research areas (from 811 tons/year to 4,805 tons/year), while the catch from wild fisheries doubled</p> <p>Higher incomes for both indigenous and commercial fishers were seen due to sales of paiche meat:</p> <ul style="list-style-type: none"> ● 379 indigenous fishers increased their income by 47.5% ● 393 commercial fishers increased their income by 35.5%
Cambodia: Enhanced productivity and diversity of homestead gardens	Fish nurseries and hatcheries Rural households with home gardens and fish ponds	<p>Increased the gross incomes of participating households by an average of CA\$374/year, providing a 10-year net monetary benefit of CA\$626 per household when compared to existing homestead production methods in place (base case)</p> <p>By the end of the project, more than half of the households were in Cambodia's fourth and highest wealth quintiles</p>

Table 3 (cont.): Key CIFSRF Phase 2 contributions to increasing incomes

Country/research focus	Who benefited	Main contributions to improved income
Colombia: Nutritious and higher-yielding potatoes	2,490 farmers (51% women) directly benefited from the project, and 1,571 (56% women) indirectly benefited through information dissemination 133 smallholder groups growing seed potato 500 households of smallholder home gardeners	18% higher incomes for farmers growing the new potato varieties New community groups called <i>Shagras para la vida</i> (Home gardens for life) have recovered indigenous knowledge (e.g. more organic agriculture) and increased incomes, household consumption of fruits and vegetables, and dietary diversity
Ethiopia: Scaling up of pulse innovations	Smallholders growing pulses: 51,000 farmers reached (42% women) Smallholder seed growers Women vendors of Guts Agro processed chickpea snacks	By double cropping with chickpeas after harvesting their main cereal crops, farmers gained an average of 3,500 Birr (approx. CA\$160) per year in extra income. This strategy also used off-season labour and available land The participating farmers can now produce two crops on the same land in one growing season (e.g. farmers produced chickpeas after harvesting maize). They can also sell the produced chickpea seed at a premium price
Ghana: Using ICTs for agricultural extension	500,687 farmers (34.8% women) reached with information about higher-yielding technologies and practices (486,578 farmers reached by radio, 14,109 reached through mobile-equipped field agents) 174,821 of these farmers (34.8% women) adopted improved technologies or management practices in 70 districts across five regions (163,562 for radio and 11,259 for field agent)	Improved maize practices resulted in a 229.9% average production increase among participating farmers (increase of 1.3 tons/hectare in total), representing an additional CA\$548

Country/research focus	Who benefited	Main contributions to improved income
India: Small millets	Increased the capacity of end-users to operate processing equipment: <ul style="list-style-type: none"> ● 33 village-level processors ● 25 small-scale processors ● 3 medium-scale processors ● 7 farmer producer organizations ● 3 food companies ● 198 prospective buyers ● 62 promoters 	<p>Additional income and employment resulted in many small-millet processing units for women. New income generation opportunity was created for 55 entrepreneurs; they earned annual income in the range of Rs. 36,000 to Rs. 50,000 (approx. CA\$673–\$935)</p> <p>Most of the millet porridge cart vendors involved in the project increased their monthly income by Rs. 2,000 to Rs. 3,000 (CA\$37–\$56)</p> <p>Since the start of the project, 173 processing units have been supplied to processors of small millets in 54 districts in 10 states. During the project period, 60 new regional-level processors entered the value chain; they earned annual income in the range of Rs. 100,000 to Rs. 240,000 (CA\$1,870–\$4,489)</p>
Nepal: Sustainable terrace farming	Smallholders in hill villages with terraced land growing diverse crops: <ul style="list-style-type: none"> ● Reached more than 260,000 people in 9 districts with SAK innovations ● Of the 56,445 products sold (80% women users), 25,955 were fully paid for by farmers and 30,490 were subsidized by NGOs ● 46 products and practices field tested by farmers, 10 products and 11 practices selected and improved as “champion SAKs” for scaling up ● 150 additional best practices were included in the SAK extension picture book and smaller booklets ● 64,795 farmers (79% women) are using these practices <p>Retailers of seeds and tools</p>	<p>On-farm terrace testing demonstrated income impacts of up to hundreds of dollars per household from individual agronomic innovations (e.g. intercropping). Such crops are helping smallholder farmers earn money from previously underused land</p> <p>New techniques for growing high-protein legumes and micronutrient-rich vegetables on underused terrace walls (e.g. yams planted in sacks at the base of the wall) earned families up to CA\$200/season</p> <p>Farmer net incomes increased by 33%–137% due to intercropping legumes with maize, millet, wheat, and mustard</p> <p>A package that combines plastic greenhouses, drip irrigation, and tarpaulin-lined ponds increased incomes by CA\$100–\$250 per household for a season</p>

Table 3 (cont.): Key CIFSRF Phase 2 contributions to increasing incomes

Country/research focus	Who benefited	Main contributions to improved income
Vietnam: Processing complementary foods	<p>A facility was established under a cost-sharing agreement between NINFOOD, the government agency Nutritional Food Science and Nutrition Service Center, and a local woman entrepreneur</p> <p>2,913 consumers purchased 28,133 sachets of ECOSUN Chao Ngon porridge (CA\$0.14 each) during the market launch</p> <p>9 mini promotional events were held in project cooperatives</p>	<p>This market-driven model is reducing reliance on imported fortified foods, creating a higher and more stable source of income for smallholder women farmers and providing sustainable food security for 20,000 women living in rural Vietnam</p> <p>Under the model, farmers sell their produce to a small-scale food processing plant that processes and fortifies the food and then distributes it through local family-owned convenience stores</p> <p>The franchising model provides small-scale farmers with a stable income and commitment to purchase produce from the 17 smallholder farming families in the Song Kim Collective (mushrooms, carrots, squash, and sweet leaf)</p>
West Africa: Indigenous vegetables and micro-dose fertilization	<p>338,000 smallholder vegetable farmers (51% women)</p> <p>21,000 vegetable traders (65% women in Nigeria; 72% women in Benin)</p> <p>315 processors in Nigeria (67% women) and 9,000 in Benin (95% women)</p> <p>576 seed growers and sellers</p>	<p>Incomes from indigenous vegetable enterprises more than tripled during the peak season in Nigeria (from approx. CA\$700–CA\$2,100/week)</p> <p>Vegetable traders saw a 120% rise in revenues in Nigeria and a 90% rise in Benin, with the primary beneficiaries being women</p> <p>Osun Government Youth Empowerment Scheme farmers reported profits from sales of indigenous vegetables of up to 300% of their investment</p>

Source: Abridged and updated from Wiggins, S., Keats, S., Löwe, A., and Shaxson, L. 2018. Canadian International Food Security Research Fund: Synthesis of income effects of Phase 2 projects. London: Overseas Development Institute. <http://hdl.handle.net/10625/57232>.

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Amdane Bouraima explains to the Gateway Supermarket seller the benefits of value-added products fortified with extracts from indigenous vegetables, Parakou, Benin.

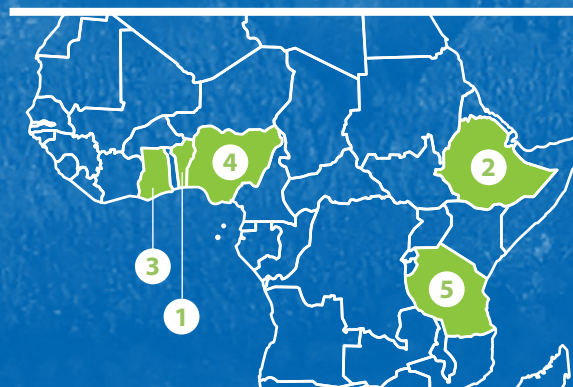
- 1 FAO. 2008. An Introduction to the Basic Concepts of Food Security: Food Security Information for Action. Practical Guides. Rome: Food and Agriculture Organization of the United Nations. <http://www.fao.org/docrep/013/al936e/al936e00.pdf>.
- 2 Keats, Sharada, & Wiggins, Steve. 2014. Future diets: Implications for agriculture and food prices. Report. London: Overseas Development Institute. <https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8776.pdf>.
- 3 Arias, P., Hallam, D., Krivonos, E., and Morrison, J. 2013. Smallholder Integration in Changing Food Markets. Rome: Food and Agriculture Organization of the United Nations.
- 4 World Bank. 2007. From Agriculture to Nutrition: Pathways, Synergies and Outcomes. Washington, DC: Agricultural & Rural Development Department, World Bank with International Food Policy Research Institute.
- 5 Smith, L. and Haddad, L. 2014. Reducing child undernutrition: Past drivers and priorities for the post-MDG era. IDS Working Paper 441. Brighton: Institute of Development Studies.
- 6 Wiggins, S., Keats, S., Löwe, A., and Shaxson, L. 2018. Canadian International Food Security Research Fund: Synthesis of income effects of Phase 2 projects. London: Overseas Development Institute. <http://hdl.handle.net/10625/57232>.
- 7 Sri Lanka Export Development Board. December 2017. Growth of Demand for Coconut in the Global Market. Available online at <http://www.srilankabusiness.com/blog/growth-of-global-demand-for-coconut.html>.
- 8 Staal et al. 2009. Strategic investment in livestock development as a vehicle for rural livelihoods. Bill and Melinda Gates Foundation – ILRI Knowledge Generation Project Report. Nairobi: International Livestock Research Institute. Cited in Herrero, M., Havlik, P., McIntire, J., Palazzo, A., and Valin, H. 2014. African Livestock Futures: Realizing the Potential of Livestock for Food Security, Poverty Reduction and the Environment in Sub-Saharan Africa. Geneva: Office of the Special Representative of the UN Secretary General for Food Security and Nutrition and the United Nations System Influenza Coordination (UNSIC).

Informing policy with CIFSRF research evidence: 2009–2018

At a glance:

- CIFSRF results informed 29 food security policies, plans, or programs in 10 countries
- 97% of projects engaged with policymakers and influencers (27 in Canada and 38 in developing countries)
- Policymakers mentioned results of 90% of projects (23 in Canada and 35 in developing countries)
- 72 policy briefs were developed
- Partners and staff organized 49 knowledge-sharing events targeting policymakers

Africa



1 Benin

- Value-added products fortified with extracts from indigenous vegetables are being certified by the Ministry of Agriculture's Food and Applied Nutrition branch

2 Ethiopia

- Chickpeas were recognized as a crop of national interest
- New chickpea varieties are being distributed to farmers by the Bureau of Agriculture to mitigate drought
- Double cropping cereals and pulses is now recommended in government guidelines

3 Ghana

- National register of private extension service providers was created to meet farmer demand

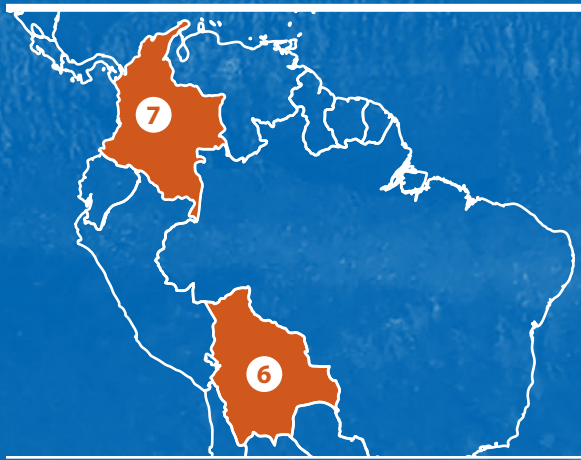
4 Nigeria

- Standards were adopted and certification was expedited for bread and other products fortified with indigenous vegetable extracts

5 Tanzania

- Locally produced vitamin A–fortified crude sunflower oil was approved by the National Food and Drug Authority
- The fortification of crude edible oil facilitated the implementation of the National Food Fortification Policy
- Seven policy changes were adopted to expedite the registration of new pulse seed varieties, lower input costs, and expand community-based seed systems for new varieties
- The Communications Regulatory Authority is exploring how policy and regulation can improve farmers' access to information

Latin America



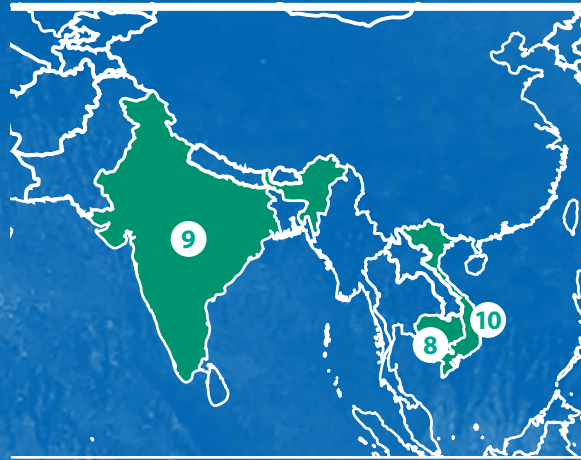
6 Bolivia

- Sustainable Fisheries and Aquaculture Law was proclaimed in 2017
- Guidelines were developed with the National Food Safety Authority for fish handling and quality standards
- Fisheries co-management agreements were formalized with indigenous communities
- 14 fishing and 12 fish farming associations were granted legal status

7 Colombia

- Groups of rural entrepreneurs were established by the National Program for the Promotion of Potatoes Consumption to support seed production in four provinces
- Leadership schools focused on food security, nutrition, and food sovereignty were established in 13 municipalities and indigenous territories through an agreement with mayors and the Departmental Health Institute

Asia



8 Cambodia

- Current and upcoming National Strategy for Food Security and Nutrition was informed by homestead gardening research
- Polyculture fishing model was incorporated into the 2019–2023 strategy

9 India

- Recommendations on consumption of small millets were adopted by the Ministry of Agriculture and Farmers' Welfare
- The Tamil Nadu government is including small millet food products in public food schemes
- Small millet product standards and regulations were adopted by the Food Safety and Standards Authority of India
- National food safety standards and regulations for fortified foods now include double-fortified salt
- Enhanced Freshness Formulation was incorporated into state policy in Tamil Nadu to reduce soft-fruit crop losses

10 Vietnam

- A National Plan of Action for Nutrition (NPAN) was informed by research on fortified complementary foods
- Legislation to address food security for poor and disaster-affected areas as well as policies to encourage private sector investment in nutritional products, especially for pregnant women and children under 5, was proposed through NPAN

How we achieved it









4

Strengthening gender equality in agriculture and food security

Approaches

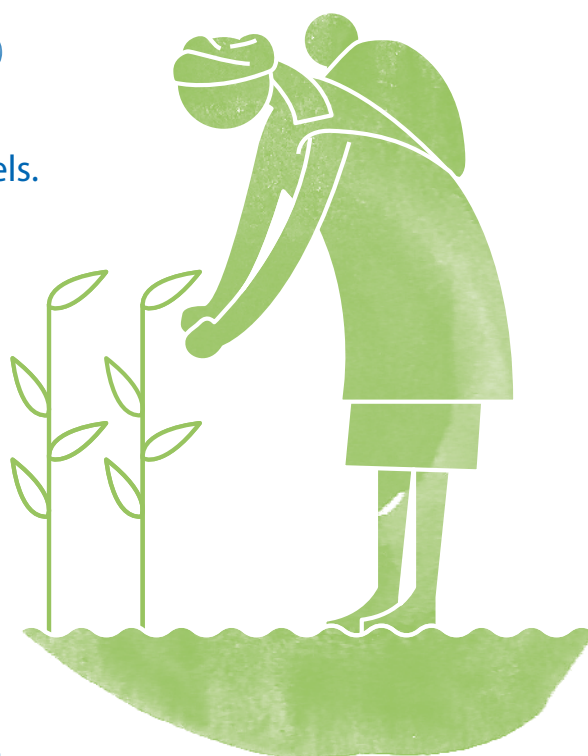
Gender integration strategies occurred at multiple levels.

For smallholder farmers and community members

- increasing recognition of women's roles in agriculture
- redistributing labour and resources
- building women's agency
- increasing social inclusion

For the project teams and research process

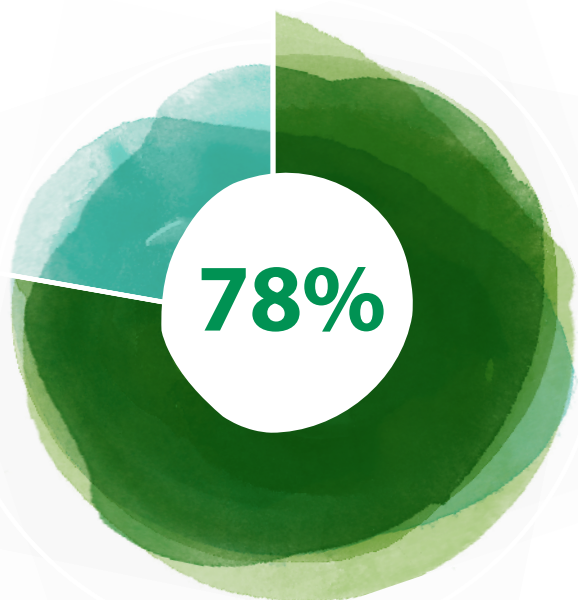
- increasing the gender analysis capacity of research teams
- applying a gender lens throughout the research cycle
- accounting for progress in meeting gender objectives
- generating evidence on gender-responsive research practices



Best practices

- Use a layered combination of strategies to achieve more gender-transformative results
- Dedicate gender expertise and “ring-fenced” funding to enable more transformative outcomes
- Unpack assumptions about gender and articulate a theory of change on women's empowerment
- Address gender constraints more effectively using interdisciplinary and qualitative research rather than biophysical

Results



of CIFSRF projects increased women's access to knowledge, skills, and resources

33% of projects actively empowered women by increasing their voice and leadership, recognizing their value, providing more control over resources and decisions, and increasing their participation in organizations

Women's incomes were increased, their nutrition was improved, and their work drudgery was reduced

All projects implemented gender strategies; **426** researchers participated in gender training

42% of farmers involved in testing innovations were women

45% of farmers who received technical training were women

Women made up **37%** of the researchers involved in CIFSRF

Women made up **58%** of the graduate students involved in CIFSRF

Aggregate global data shows that women make up approximately 43% of the agricultural labour force in developing countries, ranging from about 20% in Latin America to some 50% in Africa.¹ Yet their role in production, processing, and marketing remains undervalued and largely unsupported. Women's productivity and opportunities are constrained by many factors, including lack of credit, lack of secure land tenure, and less access to agricultural inputs and training. Given women's important role in agriculture and family well-being, the resulting productivity gaps undermine progress in addressing food and nutrition security.

Gender equality and the empowerment of women is important not only for women themselves, but for overall development progress. Based on a recent analysis in 141 countries, the World Bank estimates that the global loss in human capital due to gender inequality is more than US\$160 trillion.²

To date, efforts to address women's undervalued role in agriculture have largely been applied through "gender mainstreaming" interventions that attempt to close the gender gaps in resource access and productivity and that target women as beneficiaries. But more recent analyses (e.g. Hartle 2017³; Kantor 2013⁴; McDougall et al. 2015⁵) suggest that gender-transformative approaches are needed to strengthen gender equality across food chains and food systems. These approaches demand going beyond targeting women as beneficiaries to addressing barriers embedded in the underlying gender and social norms that keep both men and women from fully participating in and benefiting from the sector.

Approaches

Gender was a cross-cutting theme in both phases of the Canadian International Food Security Research Fund (CIFSRF) and was reflected in the program's intended outcomes. CIFSRF has helped Canada deliver on its new Feminist International Assistance Policy by ensuring that women benefit from investments in sustainable agriculture. The program recognized that women and girls are the least food secure despite being the main food producers in developing countries, so women and girls were targeted as the primary agents of change and the main program beneficiaries. By extension, all supported projects had an intentional focus on gender.

At the program level

CIFSRF was guided by a gender strategy that evolved over the program's nine years. The initial strategy focused on considering women's specific needs in research design, targeting the participation of women in the research activities, and aiming for positive research impacts on women. These three areas of focus were consistent during the initial stages of CIFSRF.

The gender strategy evolved during Phase 2 to include a more specific focus on the thematic areas of the program — technologies, markets, nutrition, and policies — and how to address the gender inequalities inherent in these areas. It also began to shift research attention to the underlying social and gender norms that contribute to gender inequality.

A key feature of the program was the consistent focus on gender integration throughout the program funding cycle.⁶ Gender was considered at all stages, from the design of calls for proposals to the evaluation of project outcomes. The program also supported capacity building and ongoing learning among research partners to strengthen their ability to address gender within their projects. The program offered stand-alone training workshops and encouraged projects to undertake gender audits using scorecards. This evolved to a more systematic approach, with capacity building and learning tailored to the needs of specific CIFSRF projects.

Within projects

The degree to which projects integrated gender analysis varied. Some targeted women as project partners who would see tangible benefits, while others empowered women by addressing the underlying gender and social norms. These differences reflected the nature of the research, the capacities and assumptions of the teams, and other variables.

An analysis of gender integration in Phase 2 CIFSRF projects conducted by the Royal Tropical Institute⁷

distinguished between gender integration research strategies and gender outcomes. As shown in Table 4, Danielsen et al. identify the eight main categories of strategies that were used to integrate a gender lens within project research. Four of these relate to the content or focus of the research and four relate to research processes. Each of these strategies reflects different diagnoses of the problem and assumptions about gender roles and therefore led to different research approaches.

Table 4: Gender integration strategies used in CIFSRF projects

Research content strategies	Research process strategies
1. Increasing recognition of women's roles in agriculture <ul style="list-style-type: none"> ● gender sensitization ● engaging men ● making women's contributions more visible 	5. Increasing the gender analysis capacity of teams <ul style="list-style-type: none"> ● gender training ● gender expertise ● partnering ● professional development opportunities for women
2. Redistributing labour and resources <ul style="list-style-type: none"> ● reducing labour and time ● increasing access to tangible resources 	6. Applying a gender lens throughout the research cycle <ul style="list-style-type: none"> ● gender-responsive design and planning ● using gender analysis as research methodology ● budgets for gender activities ● gender-responsive data collection ● gender-responsive monitoring ● gender-responsive communication and dissemination
3. Building women's agency <ul style="list-style-type: none"> ● promoting women's leadership ● supporting collective action ● increasing women's decision making 	7. Accounting for progress in meeting gender objectives <ul style="list-style-type: none"> ● project gender strategies ● gender-responsive targets
4. Increasing social inclusion <ul style="list-style-type: none"> ● participatory research and priority setting ● recognizing intersectionality 	8. Generating evidence on gender-responsive research practices <ul style="list-style-type: none"> ● addressing knowledge gaps ● investigating gender-strategic research questions

Source: Adapted from Danielsen, K., Wong, F.F., McLachlin, D., and Sarapura, S. 2018. Typologies of Change: Gender Integration in Agriculture and Food Security Research. Amsterdam: Royal Tropical Institute. <http://hdl.handle.net/10625/57120>.

Results

The gender outcomes of CIFSRF projects can be viewed in three categories on a continuum that ranges from women's basic involvement in or exposure to project activities to an increase in their agency:⁸

- **"Women reached"** outcomes refer to women's involvement (in the broadest sense) as participants in or targets of project activities.
- **"Women accessing resources and benefits"** outcomes refer to women's increased opportunities and/or abilities to use resources and derived benefits including food, health, reduced drudgery, and income.
- **"Women empowered"** outcomes refer to women's strengthened capacities to make choices on their own and voice concerns that are listened to and acted upon. Here, unequal gender relations that constrain women can be challenged.

These outcomes can be but are not necessarily interrelated — projects that reach women do not automatically benefit them, and activities that benefit women don't necessarily empower them.

How projects reached women

All CIFSRF projects validated and increased visibility of women's roles in agriculture, but most went well beyond that. Each project's focus guided the way women were reached. For example, projects highlighting nutrition were more likely to reach women as consumers, mothers, and/or meal preparers. Projects focusing on improved access to resources, markets, and inputs were more likely to reach women as farmers, entrepreneurs, business owners, and/or employees.

The ways that projects targeted women were built on assumptions about gender roles. Some, such as projects that focused on nutrition education or developing women's capacities in food production and marketing, built on status quo gender roles that reinforced widely held understandings of women's roles in the family. Most projects explicitly

recognized women as farmers and knowledge holders and involved them as active partners in testing agricultural innovations. While the approach was not ground breaking, including women in research and training activities helped to validate their important contributions to agriculture and increase their visibility. A few projects went further, working with women in the full complexity of their many overlapping social identities, including gender, class, ethnicity, and age, with specific project interventions taking these intersecting dimensions into account. These projects developed awareness of how these identities create or reinforce barriers for women's access to and control over resources.

Increasing women's access to resources and benefits

Fourteen CIFSRF projects increased women's access to skills, knowledge, and productive resources. Women gained knowledge and skills about agricultural practices, business and marketing, and nutrition and health. For example, women farmers learned how to sustainably increase yields under various conditions, diversify their crops, use new tools and technologies, and manage and run micro and small enterprises.

Projects improved women's access to productive resources such as credit to invest with, fertilizer and seed varieties to increase yields, and improved tools and techniques that saved time or improved production. The benefits of these resources included **increased income**. Families participating in the

CIFSRF Phase 2 gender outcomes

- **100%** of projects reached and involved women
- **78%** of projects increased women's access to knowledge, skills, and resources
- **33%** of projects actively empowered women
- **42%** of farmers involved in testing innovations were women (713,905 of 1,694,504 in total)

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Delphine Ayedamou of the peri-urban co-op Soudomse shows her freshly harvested indigenous vegetable crop, Parakou, Benin.

Amazon Fish for Food project, for example, reported that their yearly earnings more than doubled (from CA\$10,114/year to CA\$25,046/year). Targeted business development support in several projects also helped women entrepreneurs increase their incomes.



Some projects **reduced drudgery** and the physical effort expended on agricultural activities. This freed up time for women to engage in leisure or other economic activities and in some cases enabled them to maintain family farms in communities heavily affected by male out-migration. In Nepal, for example, hand-held corn shellers saved each farmer 36 hours of labour/season. Millet dehullers introduced in India saved women 1.25 to 2 hours per session. Interestingly, men's involvement in these traditional "women's tasks" increased with mechanization in both projects.



Projects **increased family consumption of nutritious foods**, which is especially important for women and children, who tend to be most vulnerable to malnutrition. In Cambodia, the scale-up of homestead food production improved child-feeding practices and consumption of vegetables and fish by women in particular. Similarly, research on fermented foods in Kenya, Tanzania, and Uganda increased women's and children's consumption of yogurt. Fish-farming families in Bolivia gained an added source of protein by increasing their fish consumption by an average of 12 kg/year. In Ethiopia, scaling up pulse production and consumption resulted in a significant increase in children's dietary diversity. In Tanzania, promoting locally processed fortified sunflower oil helped reduce vitamin A deficiency in both women and children.

Empowering women

Six CIFSRF projects helped to empower women in various ways, in addition to providing material benefits. These projects did so by increasing the recognition of women's role in agriculture, contributing to changes in gender norms, increasing women's control over decision making, and/or promoting their participation in leadership.

All six projects enhanced how various stakeholders valued and recognized women in roles such as knowledge holders, research partners, and producers, thereby raising their self-esteem and social status. In some cases it also helped men develop a greater appreciation for the value of women's traditional roles. As one male participant in Colombia said, "What I make in a month would not be enough to pay for the work of my wife."

The Amazon Fish for Food project increased women's participation in fish farmer organizations and their access to training, which in turn improved their household status and formal leadership in the organizations. It also **improved women's control over resources and participation in decision making**. In a survey, 83% of fish-farming households stated that women had an equal voice in decisions on building new ponds.



Some projects increased representation of **women in formal leadership positions** at multiple levels, including as individual leaders of producer groups, and as collective leaders of women's savings groups. In Colombia, for example, women occupied 50% of leadership positions in various committees linked to project activities. In Bolivia, the representation of women on the boards of aquaculture associations in core study areas more than doubled, from 19% to 40%. Projects that empowered women helped them gain confidence in



their ability to speak in public, to engage in dialogue with local government agencies, and to voice their concerns about women's rights, including violence against women.

While evidence of **changes in gender norms and behaviour** was limited, there were signs of projects contributing to changes in the division of labour and redistribution of responsibilities between women and men. In Colombia, men and women were both encouraged to critically examine prevailing social norms around gender. This critical reflection may

have helped to challenge a prevalent male-dominant culture and improve relations between men and women participants. The study found less domestic violence by men, with benefits for all members of the communities involved.

Empowering women through homestead production

In rural Cambodia, many people believe that a woman's place is in the home. Indeed, many women's lives are tied to their homesteads, where they play a crucial but largely undervalued role in ensuring family well-being. Tending a vegetable garden helps to supplement meagre diets and improves family nutrition and incomes, but can it also empower women?

The Scaling Up Homestead Food Production project worked with small farmers to increase home gardening production and diversify diets through small-scale fish farming and raising poultry. Phase 1 research showed that these interventions increased household incomes and food security. Among women, the increase in animal protein targeted common micronutrient deficiencies, specifically by increasing iron and retinol-binding protein levels in the blood — both crucial indicators of maternal health.

Alongside the focus on farming, the research team adapted the gender-transformative [Nurturing Connections](#) curriculum for local use. Both men and women engaged in sessions that took a hard look at widely held beliefs and practices that diminish women, such as barring them from community meetings or serving them the scraps from family meals.

Along with raising incomes, the project **explicitly recognized women as farmers and knowledge holders** and involved them as legitimate research partners in testing agricultural innovations. This and their role in generating new income **increased household and community recognition** of women's roles as producers, food preparers, and mothers. It **strengthened women's influence** on decisions related to food production, which positively influenced what food was consumed in the household. Women who contributed to household food production also, to some extent, played a larger role in other household decisions: by the project's end, 79% of women were primary decision makers on major household spending, and women were making 90% of the decisions around farming.

There were also some signs of **change in gender roles and the distribution of labour** within participating households. Some husbands helped with cooking and animal care, while some grandfathers minded the children, leaving women more time for breastfeeding or for that most precious resource — time for themselves.

Best practices

CIFSRF's nine years of sustained focus on improving outcomes for women smallholder farmers yield important insights, even as the program's thinking on gender evolved from its early days.

Using a layered combination of strategies helps projects achieve more gender-transformative results

Embedding gender outcomes in CIFSRF's framework set an overall vision and road map for program staff, which partners acknowledged as one of the key factors behind their own integration of research strategies that addressed the issue of gender.

A project's strategy selection was key. Having a context-specific project-level gender strategy developed and "owned" by project staff appeared to be a significant factor. The six projects that achieved empowerment outcomes used a variety of strategies that addressed inequalities in gender power relations, along with tackling the technical and material barriers facing women. These included redistribution strategies that saved women time or increased their access to resources; recognition strategies that enabled men to better appreciate women's contributions to food and nutrition security; and strategies that increased women's agency, such as by helping them organize collectively or take leadership roles.

Dedicated gender expertise and "ring-fenced" funding are key to enabling more transformative outcomes

Project funding was contingent on stating gender-responsive objectives. CIFSRF used experts to provide training that increased partners' capacities in integrating gender. Project and staff capacity was key to the successful use of gender-responsive strategies. The level of gender knowledge and skills of those responsible for activity implementation and in projects addressing more complex gender dynamics was particularly important.

Having dedicated gender experts on board in early stages of project design was particularly effective. This meant that experts could influence the choice



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of project strategies and had a clear mandate to accompany the project throughout implementation. The application of gender-responsive strategies was also aided by having research partners with experience in applied action research who could tap into existing expertise, tools, and resources.

Having dedicated budget components to fund gender-related activities also influenced a project's success in achieving gender outcomes. While few projects included adequate "ring-fenced" funding (protected funding for a specific designation) for gender at the proposal stage, those that did attained gender empowerment outcomes.

▲ Small fish are a great source of micronutrients and are being introduced into the diets of farming families. Prey Veng Province, Cambodia.

Projects and programs need to unpack their assumptions about gender and articulate a theory of change on women's empowerment

While CIFSRF explicitly focused on women smallholders from its early stages, we learned that the contexts within which women are embedded and the social relations attached to gender are crucial to understanding gender differences. Programs and projects need to spell out theories of change that are explicit in their assumptions about gender. They cannot, for example, automatically assume that technical innovations will benefit women.

Over time, CIFSRF's approach to and support for gender integration evolved. The gender criteria for funding increased and became more detailed; capacity strengthening became more systematic and tailored; and the gender strategy became more visionary and integrated.

At the project level, aims need to go beyond simply reaching women as recipients of information and technologies to acknowledging their roles as legitimate knowledge holders and brokers. Merely involving women in project activities is insufficient

for women to benefit. Having a theory of change that reflects a more granular understanding of local conditions and power relations will more likely result in projects offering innovations that address gender-based barriers rather than reinforcing status quo social relations.

Interdisciplinary and qualitative research is more effective in addressing gender constraints than biophysical research alone

Given the socially embedded and context-specific nature of gender constraints in agriculture, projects that focused almost exclusively on technological innovations were less likely to benefit or empower women. In general, gender-responsive research designs used qualitative research (surveys, interviews, focus groups) to measure women's roles, needs, and constraints in their local context. Engaging with context enables projects to diagnose and respond to intersecting inequalities, such as how ethnicity or class interacted with gender divisions. Projects that matched their innovations to their specific social context were generally more successful in addressing gender inequalities.

1 FAO. 2011. State of Food and Agriculture. Rome: Food and Agriculture Organization of the United Nations.

2 Wodon, Q. T. and de la Brière, B. 2018. Unrealized Potential: The High Cost of Gender Inequality in Earnings. The Cost of Gender Inequality. Washington, DC: World Bank.

3 Hartle, M. 2017. From gender mainstreaming to empowering women in agriculture to gender transformation. *Agriculture for Development* 32, 2–6.

4 Kantor, P. 2013. Transforming gender relations: Key to positive development outcomes in aquatic agricultural systems. Penang, Malaysia: CGIAR Research Program on Aquatic Agricultural Systems.

5 McDougall, C., Cole, S., Rajaratnam, S., and Teioli, H. 2015. Implementing a gender transformative research approach: Early lessons. In Douthwaite et al., eds. *Research in Development: Learning from the CGIAR Research Program on Aquatic Agricultural Systems*. Penang, Malaysia: CGIAR Research Program on Aquatic Agricultural Systems.

6 Wong, F., McLachlin, D., Sarapura, S., and Danielsen, K. 2018. Lessons Learned Synthesis Paper: Gender integration and the Canadian International Food Security Research Fund. Amsterdam: Royal Tropical Institute. <http://hdl.handle.net/10625/57119>.

7 Danielsen, K., Wong, F., McLachlin, D., and Sarapura, S. 2018. Typologies of Change: Gender Integration in Agriculture and Food Security Research. Amsterdam: Royal Tropical Institute. <http://hdl.handle.net/10625/57120>.

8 From Royal Tropical Institute typology, inspired by Johnson et al. 2017. How do agricultural development projects aim to empower women? Insights from an analysis of project strategies. IFPRI Discussion Paper 1609. Washington, DC: International Food Policy Research Institute.

5

Scaling up food security innovations

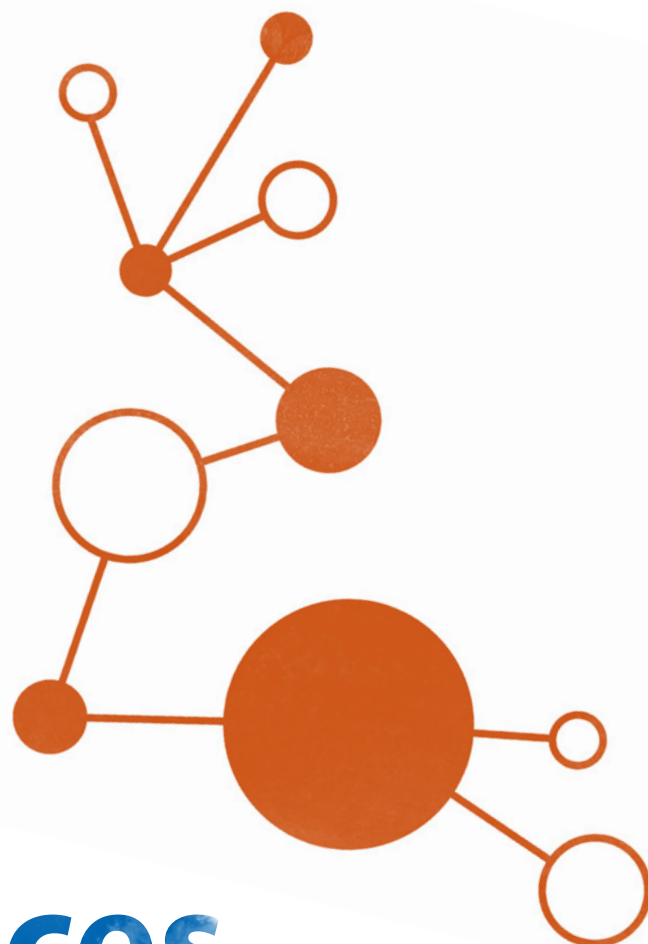




Approaches

Projects engaged with different stakeholders and used three main pathways for scaling up innovations:

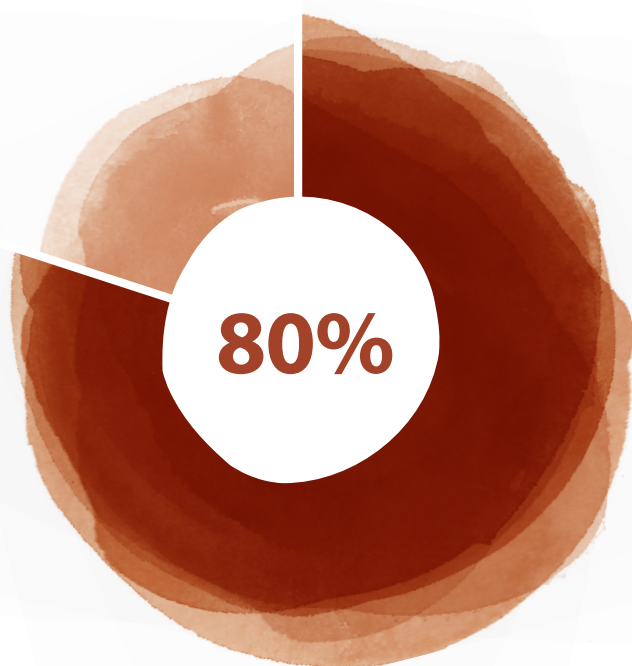
- working with the private sector and markets
- informing and influencing public policies and programs
- knowledge sharing and capacity building



Best practices

- Start with an innovation that responds to the needs of people, is grounded in scientific evidence, and is robust under various conditions
- Read the context, identify constraints, and prepare to seize opportunities
- Identify the most appropriate strategy/ pathway for scaling up that works in “the real world”
- Build leadership and commitment for the long run
- Involve the right partners who are connected to informal and formal networks and interested in both business and social impacts
- Consider scaling-up pathway and conditions from the design of the research

Results



of projects funded under CIFSRF are successfully scaling up their innovations

78 million end-users reached through CIFSRF: for example,

- salt fortified with iron and iodine arrived on the tables of **50 million** people in India
- new varieties of more nutritious potatoes were made available to **6.5 million** Colombian consumers
- **18 million** radio listeners received new knowledge on best practices to grow and consume indigenous vegetables in Benin and Nigeria
- **650,000** family members were directly reached with information on improved legume technologies through media campaigns in Tanzania – **130,000** of whom adopted the innovation
- **29** food security policies, plans, or programs were developed in **10** countries
- **36** innovations developed and tested for scaling

Given the persistence of global hunger, there has been a long-standing interest among governments, donors, and development practitioners in scaling up the positive impacts of interventions to increase food security. However, despite massive investments in research for development during the past 50 years, and considerable evidence of successfully pilot-tested innovations at the local level, the uptake of these innovations on a large scale remains limited. There is an urgent need to improve understanding of the scaling-up process to support the adoption of innovations and generate impact at scale. The discourse around scaling up took on new urgency with commitments to achieve the 2015–2030 Sustainable Development Goals.¹

The concept of scaling up agriculture research is not new.² The Green Revolution of the 1950s and 1960s introduced a suite of innovations to tens of millions of farmers. The 40% increase in grain production from 1960 to 1965 is attributed to the use of fertilizers developed during this period.³ However, Green Revolution technologies were not equally accessible to smallholder and landless farmers, and many were left behind. The large-scale adoption and insufficient control over the use of these technologies also generated long-term negative environmental impacts. Based on lessons learned from the first Green Revolution, environmental sustainability is now considered key in the development of new agricultural innovations and in determining which innovations to bring to scale.⁴

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▲ A Listening Club in the village of Liulahumba listening to radio programs, interviews with other farmers, stories and facts about soybeans. Njombe, Tanzania.

There is limited consensus on what innovations to scale and how they should be scaled, measured, and evaluated. However, two broad paradigms have emerged from the literature:

1. The **diffusion and adoption of technologies theory** suggests that through trial and sustained use, users adopt an innovation; this influences others in their social networks over time.⁵
2. The **agricultural system change theory** suggests that innovations are context-specific and cannot simply be copied across countries and regions.⁶ Approaches based on this theory typically focus on networking and interactive learning as key to making institutional changes that enhance the adoption of new technologies. This approach is consistent with participatory research, which involves farmers in the research process as a means to speed up the adoption of technology and to ensure its adaptation to meet their needs.

What does scaling up mean?

Bringing more quality benefits to more people over a wider geographic area more quickly, more equitably, and more lastingly.

IIRR 2000 in Menter et al. 2004

Approaches

The Canadian International Food Security Research Fund (CIFSRF)'s scaling-up objectives and understandings build on IDRC's long-standing experience in supporting participatory research and building institutional capacity through research for development.

At the program level

Phase 2 of CIFSRF aimed to test scaling-up methods and to achieve the scale-up of innovations that showed promise for sustainably increasing food production, raising farmers' incomes, and improving nutrition. Eleven of the 18 projects in Phase 2 built on innovation concepts tested in Phase 1, while others had been proven successful in other foundational research.

CIFSRF defines innovations as technologies, products, or models that address a specified need and are either new inventions or old ones that are applied in new ways.

Within projects

Projects followed one or more of three main scaling-up pathways:

- **working with markets:** working with private sector partners using business models (including social enterprise) to improve user access to and distribution of efficient, affordable innovations
- **informing public policies and programs:** projects informed and involved government officials at various levels to facilitate the development of policies or public mechanisms that support the scale-up of innovations
- **knowledge sharing:** using various tools and methods to communicate about new innovations and best practices that improve knowledge and influence behaviours

Within these pathways, projects also applied different elements of diffusion or systems change approaches that were dependent on the complexity of the innovation and its transferability to existing agriculture and nutrition frameworks. In some cases, particularly when an innovation was a tangible good, projects diffused the innovation and created awareness and demand through demonstrations, participatory field trials, and communications or marketing campaigns. When the innovation involved a new practice or other intangible that required a paradigm shift, project teams recognized that they needed to make system changes to facilitate uptake. This involved building new capacity through training, creating new networks or associations, or promoting policy changes.

Results

CIFSRF results are reflected in both the number of people who adopted new tools, practices, or other innovations and the insights generated on the various pathways used to reach them. For projects that recognized the need for systemic or social changes, results can also be seen in the creation of new capacities, new policies, or new structures within existing agriculture and nutrition frameworks.

Here, we explore some of the most immediate results, as seen through the lens of the pathways used within projects.

The 'Kotawala', what the locals call the shops where they come to get their monthly allotment from the government. Here they are receiving their 1 kg packet of double-fortified salt from Ajaykumar. Lohardaga, Jharkhand, India.



© IDRC/Bartay



Achieving scale through market-based approaches

Phase 2 encouraged partnerships with business-oriented organizations as a means to achieving scale. The program’s final call for proposals focused specifically on those that harnessed private sector partnerships to explore market-based approaches to scaling up. Of the 18 projects in Phase 2, 14 used some form of market mechanism to support the deployment and adoption of innovations. Even though private sector organizations represented only 7% of grantees, they constituted more than 35% of third-party organizations involved in CIFSRF research projects.



CIFSRF’s definition of “business-oriented organizations” included non-profit organizations focused on economic and business development, for-profit firms, suppliers, and service providers. Most projects involved partnerships and engagement with either national-level companies or micro, small, and medium-sized enterprises. Several also worked with business-facing intermediaries, such as producer associations, cooperatives, microfinance providers, and business-oriented non-profit organizations. Multinationals played a limited role as potential licensees and commercial distributors of new technologies that were developed and trialed for scale-up (novel livestock vaccines and hexanal-based products that extend the freshness of soft fruit).

By and large, market-oriented projects focused on tangible innovations. The challenge was to test ways of selling farmers on their benefits and delivering them in appealing and cost-effective ways. In Nepal, research focused on scaling up the use of sustainable agriculture kits (SAKs) — a selection of more than 30 products that support improved nutrition and yields and help to reduce drudgery. Two distribution models were tested with a chain of franchised small local vendors. The first involved selling small SAKs priced at CA\$10 or less, and the second was a rental model for more expensive equipment. Despite a

major earthquake, severe weather events, and an extended fuel blockade — all of which affected field testing and commercial scale-up — an innovative public–private partnership helped more than 60,000 farming households acquire SAKs (either purchasing them from a local vendor or receiving products from NGOs or government agencies). Proponents estimate that up to 260,000 people (80% of them women) benefited directly or indirectly. While it may be necessary for a third party to continue subsidizing product distribution to low-income farmers, tool and seed sales are steady and the future of these easy-to-use innovations is promising.

Informing public policies and programs

The policy context is an important factor in the environment for scaling up agricultural innovations. Although all CIFSRF projects engaged with policymakers to some degree, in some cases the resulting shifts in public policies or programs were instrumental for adopting food security and nutrition innovations on a wide scale.

The public sector has an important role to play in developing innovations and ensuring that they reach especially poor and vulnerable populations. Public or government support through subsidies, vouchers, and other incentives helps farmers with innovation adaptation costs. Ample research evidence suggests that government support is important for the success of innovation uptake, particularly in the early stages of scaling up.⁷

Research in India on scaling up the manufacture, distribution, and consumption of double-fortified salt (DFS — salt fortified with iodine and iron to address widespread micronutrient deficiencies) achieved impressive results by working with state public distribution systems. Three Indian states procured the locally manufactured DFS, which reached an estimated 50 million people through the public system by mid-2018. While electoral processes and other political dynamics delayed some aspects of the research, the effort highlights the tremendous speed and scale at which public distribution can bring nutritionally fortified foods to vulnerable populations, especially when subsidies are added to overcome price barriers.

Knowledge sharing

All CIFSRF projects used knowledge exchange to scale up innovations and to document lessons learned about various knowledge-sharing methods. Indeed, knowledge sharing is embedded in participatory research processes, with both researchers and participating farmers and other stakeholders learning through hands-on processes

such as demonstration plots, training workshops, peer networking, and consultative platforms that are intrinsic to many projects.

One project used both hands-on learning and mass media campaigns to promote indigenous vegetable production and consumption in West Africa. Two models were used to reach and involve farmers: a **satellite approach** that disseminated agronomic

Massava project: Scaling up fortified oil through local markets in Tanzania

Sokoine University of Agriculture and the University of Waterloo aimed to address widespread vitamin A deficiency by demonstrating that crude sunflower oil, which is less expensive than refined oil, could be locally fortified with retinol and retain its vitamin A levels under the typical local sales conditions.

The project strengthened the capacity of three local small and medium-sized enterprises (SMEs) to produce the fortified oil using “gold standard” stainless steel mixing tanks and worked with more than 300 retailers to distribute the product to target beneficiaries. Initial sales of 1-litre bottles of fortified sunflower oil began in October 2015. At that time, more than 500,000 e-vouchers (consumer-oriented discounts) were distributed to low-income households to encourage sales.

Sales of the vitamin A–fortified oil were also supported by behaviour change communication (BCC) campaigns aiming to raise consumer awareness of the health benefits of the oil. The project’s BCC strategies were targeted to various audiences (women, youth, etc.) and comprised a wide range of activities such as clinic and cooking demonstrations, road shows, and cultural shows. The project also marketed the fortified oil with posters and other promotional materials at social events such as bicycle races and soccer games.

However, mid-term project assessment data revealed that sales of 1-litre bottles were lower than expected because rural low-income households could only afford to purchase oil in smaller quantities or scoops (approximately 250 ml to 500 ml). Further, the project found that beneficiaries made little use of the e-vouchers because oil was purchased by different household members, including children.

As a result, the project took several measures to improve the service delivery of its innovation. Larger container sizes of fortified sunflower oil (5, 10, and 20 litres) were introduced so that retailers could sell the oil to consumers in smaller amounts. The project also discontinued the e-vouchers (a household subsidy) in favour of retailer-oriented discounts (e-wallet) to improve sales. In all, 142,000 litres of fortified oil were produced and sold through a network of 319 retailers — enough for almost half a million people to consume for one week.

Evidence suggests that consumer education efforts had some positive effects: sales continued in project areas after the subsidy ended in May 2017, and they expanded into other areas. However, production costs of vitamin-fortified oil are higher due to more stringent regulatory standards. Therefore, local SMEs struggled to remain profitable due to fluctuating prices, high transport costs, and competition from cheaper oils.

knowledge and techniques through the public extension system, and a more collaborative model, called **“innovation platform,”** which brought together various stakeholders in production and value chains to share knowledge.

The innovation platform model proved more effective for scaling up. It improved interaction among key actors and allowed them to jointly solve problems. When a lack of transportation emerged as an impediment to farmers reaching urban markets, the project team invited trucking companies into the innovation platform to address the problem. This model also helped to close key gaps between male and female farmers. Altogether, the project reached 337,931 farmers in Benin and Nigeria, more than half of them women.

The project also made extensive use of mass media to reach the general public, most notably via a weekly radio drama called *Ramo elefo* (the vegetable vendor), which packaged nutrition and cultivation advice in an entertaining format. The program reached up to 8 million people in Benin and more than 10 million in Nigeria. Listener surveys showed that the format was an effective way to reach women. The surveys also demonstrated that listeners improved their awareness of proper vegetable bed preparation (36.3%) and value-added options for indigenous vegetables (12.5%). Proponents credit a combination of mass awareness and demonstration activities for increasing the cultivation of *igbagba* (African eggplant) to 39.4% (from 1.33%) and *teteatetedaye* (amaranth) to 39.4% (from 3.33%).



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▲ William Lupenza provides training on best agronomic practices for soybeans, N'Gonde, Tanzania.

Best practices

Scaling up is a long-term process that is dependent on many factors. While some projects significantly extended their reach in only two to three years, others may yet prove to be equally significant because of the groundwork they laid by building capacity within local systems for adoption at scale.

We observed five key conditions that should be met to successfully widen the uptake and impact of an innovation.

1. Start with a solid innovation

An innovation is most likely to be adopted at scale if it

- responds to a crucial need felt by many people
- has strong scientific evidence supporting it
- is robust enough to perform in different conditions
- is easily incorporated and adapted into local practice

All CIFSRF projects employed participatory research measures that included target populations in the design and implementation of innovations. Innovations were backed by evidence and the conceptualization of innovation ideas were rigorously tested using qualitative and quantitative methodologies and indicators. Close collaboration with end-users allowed project teams to tailor innovations to local contextual needs and constraints. In Nepal, for example, producers expressed a clear need for easy-to-use, affordable tools that increase yields and reduce the hardship of working steep terraced terrain. The adoption of innovations from the agriculture toolkit was facilitated by the fact that it did not require major shifts in practice and it provided return on investment.

2. Find the right model for scaling up

An innovation is more likely to scale up successfully if it can demonstrate positive net returns and ensure profitability, even as demand increases and contexts evolve. Thus, it is important for project teams to select appropriate scaling-up pathways that respond effectively to local needs.

To reach diverse end-users, both men and women, CIFSRF projects typically used more than one pathway to scale up their innovations. Market-based approaches were best suited to innovations that offer a clear and tangible benefit, such as financial returns or a reduced workload. In India there is a clear demand for hexanal-based sprays, given that farmers earned an extra CA\$200/acre due to reduced fruit loss.

However, innovations focused on nutritional outcomes, such as increasing the consumption of pulses or of vitamin A, may not be viable through market mechanisms alone. These innovations require policy intervention. The rapid scale-up of double-fortified salt in India demonstrated the efficacy of using public distribution systems for what is essentially a public good — improved health through better nutrition. Ongoing public investment may also be necessary where sustained changes in agricultural practice and systems are required.

3. Find the right partners

Multiple studies stressed the importance and leadership of varied stakeholders at different stages of the research-to-development continuum. Researchers play a stronger role in the development/testing stages of innovations than during their scale-up, but CIFSRF experience shows that even for upstream research such as vaccine development, it is important to address scaling up and deployment from a project's onset to ensure that the needs and preferences of end-users (especially women) are considered and met. Projects must therefore work with multiple partners with varying skills and connections to networks to co-develop and implement effective and practical scaling-up models that are effective in low-income contexts.

The most efficient partnerships built on a shared mindset and considered both business models and social impacts. Section 6 sheds more light on how Canadian and Southern partners collaborated to address the challenge of scaling.

4. Read the context, troubleshoot, and seize opportunities

A number of conditions must converge for scaling to succeed — timing and chance play critical roles. Good partners are responsive to the environment and prepared to adapt to changing situations. All CIFSRF projects that involved new formulations or new technologies (novel livestock vaccines, nanotech applications in fruit crop loss, fortified crude sunflower oil, and double-fortified salt, for example) had to run a gauntlet of regulatory requirements. The two vaccine projects found synergies in their work and are collaborating as they seek registration and commercialization. In Cambodia, an effort to scale up homestead gardening made important changes to its approach after earlier research showed that families wanted more choice in what they would produce. In Nepal, partners believed that distribution was their only challenge, but experience showed that product-use information was also crucial, so partners produced a graphic handbook of best practices and ramped up advertising and outreach.

5. Build leadership for the long run

Seeing durable results at scale takes long-term commitment and demands leadership from “champions” who can take the innovation beyond project timeframes and boundaries. Leadership in CIFSRF projects was developed in several ways, such as supporting master’s and PhD students; building the scientific/technical expertise needed to sustain innovations; and providing training, microcredit, and other support to producer associations to pioneer and demonstrate the viability of new practices or cultivars.

In Colombia, for example, new groups were established to lead the production and marketing of quality-certified seeds. In Bolivia, fisher associations are now formally recognized as partners in sustainable fisheries management.

Some of the widest reach was achieved through policy engagement. Bolivian fisheries, Colombian potato production, and fortified salt in India had champions within government who spearheaded the policy changes and public investment necessary to scale up food security and nutrition innovations.

- 1 World Bank. 2003. Scaling-Up the Impact of Good Practices in Rural Development: A Working Paper to Support Implementation of the World Bank’s Rural Development Strategy (report number: 26031). http://www-wds.worldbank.org/servlet/WDSContentServer/IW3P/IB/2004/01/30/000160016_20040130163125/Rendered/PDF/260310White0co1e1up1final1formatted.pdf.
- 2 Menter, H., Kaaria, S., Johnson, N., and Ashby, J. (2004). Scaling up. In Pachico, D. and Fujisaka, S. (eds.), *Scaling Up and Out: Achieving Widespread Impact through Agricultural Research*. Cali, Colombia: International Centre for Tropical Agriculture (CIAT), 9–23.
- 3 Srinivas, M.N. 2002. Science, technology and rural development in India. In Srinivas, M.N. *Collected Essays*, 414–28. New Delhi: Oxford University Press.
- 4 Consultative Group on International Agricultural Research. 2011. *Changing Agricultural Research in a Changing World: A Strategy and Results Framework for the Reformed CGIAR*. Montpellier: CGIAR Consortium.

- 5 Rogers, Everett M. 1995. *Diffusion of Innovations*. 4th ed. New York: The Free Press. Rogers identifies four main elements that influence the spread of a new innovation: the innovation itself, communication channels, time, and a social system. First, the innovation is defined by the characteristics of relative advantage, compatibility, complexity, trialability, and observability to people within the social system.
- 6 Gildemacher, Peter, and Mur, Remco. 2012. *Bringing New Ideas into Practice: Experiments with Agricultural Innovation; Learning from Research into Use in Africa (2)*. Amsterdam and Edinburgh: Royal Tropical Institute and Research Into Use.
- 7 Westermann, O., Thornton, P., Förch, W. 2015. Reaching more farmers – innovative approaches to scaling up climate smart agriculture. CCAFS Working Paper no. 135. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).





6

Building collaborative research partnerships

Approaches

Collaborative partnership for the program required

- at least one Canadian organization and at least one eligible country organization
- multidisciplinary teams involving social and natural scientists
- at least one business-oriented organization
- joint reporting and leadership
- pre-inception and inception meetings
- gender balance in project teams
- equitable budgets

Successful collaborative projects had

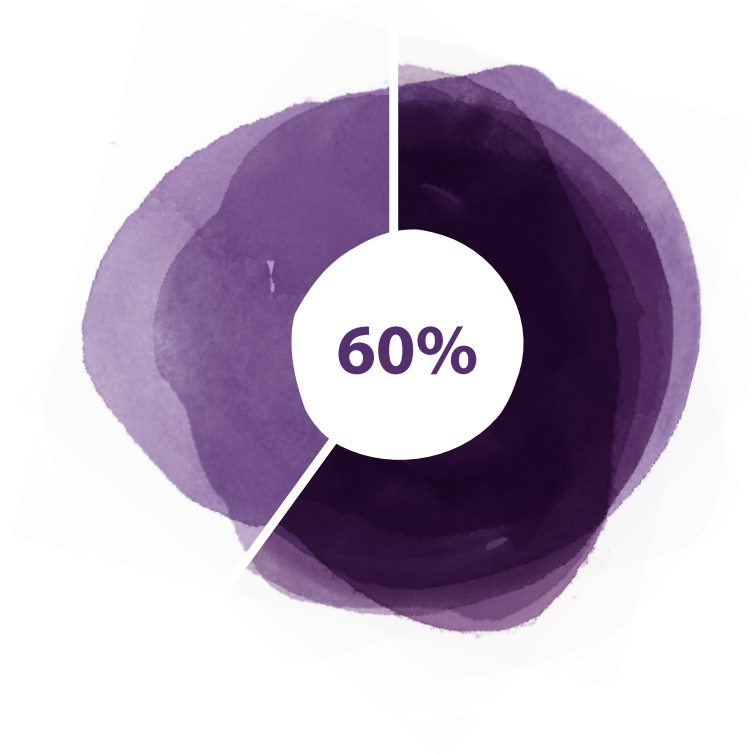
- the right mix of partners, depending on the innovation and scaling pathway
- capacity-building activities built into the research process
- memoranda of understanding (MOUs) between organizations
- steering committees
- regular meetings and communication



Best practices

- Develop a common vision to address a shared challenge
- Allow and expect flexibility within partnerships
- Have at least one strong leader per organization
- Support equity between partners through openness and transparency
- Factor in the necessary time and space to build partnerships

Results



Funding was distributed 60:40 between Southern and Canadian organizations

20 of **39** projects leveraged an additional **CA\$40.4 million** in research funding

406 graduate students (**58%** women) were involved in CIFSRF research projects

Projects produced **471** peer-reviewed articles, **375** theses, **87** books or chapters, and **72** policy briefs

167 organizations were involved in CIFSRF projects from 2009 to 2018

Partners included NGOs (**49**), universities (**44**), government bodies (**39**), private sector firms (**31**), and others (**4**)

Achieving food security has been acknowledged as one of the ‘grand challenges’ of our time, with the world population projected to reach 10 billion by 2050.¹ Addressing the complexity of the challenge — with its economic, political, social, environmental, agricultural, and human health dimensions — demands complex approaches that draw on the skills, resources, expertise, and insights of people and organizations from many disciplines and sectors.

Many observers have noted the need for **multidisciplinary research** to address the problem of food insecurity. Although multidisciplinary research addresses issues from various approaches and perspectives, it does not necessarily do so in an integrated way. Others call on a need for **interdisciplinary research** (e.g. Horton et al. 2017,² Karunasagara et al. 2016,³ Toribio et al. 2018⁴), which analyzes and synthesizes issues between disciplines in an integrated and coordinated way, and **transdisciplinary research**, where researchers develop a common theoretical understanding that integrates natural and social sciences and transcends traditional boundaries.⁵

The move towards more multidisciplinary, interdisciplinary, and transdisciplinary approaches has been one of the most significant trends in development research in recent decades. In tune with this shift, IDRC moved from programs organized around specific disciplines to problem-focused programs that draw on many areas of study.⁶

There has also been growing recognition of the need for work across sectors to address food security and nutrition given that the most immediate determinants of malnutrition are shaped by basic causes at a societal level (including the control of resources) that operate within a given economic, political, cultural, and social structure, in which various actors have specific resources. Government, the private sector, civil society organizations, and households thus all play important roles in finding solutions.



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Funding, supporting, and conducting multi-sectoral and multidisciplinary research demands highly evolved partnerships with organizations that play complementary roles united by a shared vision and objectives. Successfully managing such partnerships is by no means simple, especially when both Northern- and Southern-based institutions are involved. Ensuring the research agenda is not dominated by Northern partner priorities is a well-documented concern.⁷

Despite the many challenges, it is possible to develop effective partnerships that offer a wealth of experience from the South and North across a range of research disciplines and sectors. External reviews of CIFSRF have noted strong partnerships as a key ingredient in the program's success.⁸

▲
Asopapa Association, consisting of around 50 farmers; Dr. Maria Cecilia discussing the planting of Ocarina and Durada potatoes which she has brought with her, Sibate, Colombia.

CIFSRF has benefited from highly effective partnerships and field teams, largely owing to the people who led and participated in those teams. When it comes to research-for-development projects, the quality of teams is one of the most important factors for success.

Wiggins et al., 2018

Approaches

The second of the Canadian International Food Security Research Fund (CIFSRF)'s four key objectives was to "Build partnerships between Canadian and Southern organizations, researchers, private and public sectors, and civil society to address food security." CIFSRF's interpretation of "partnerships" includes all individuals and organizations that came together to carry out a project, including researchers and those responsible for managerial and financial aspects. It includes those who received grants directly from IDRC as well as third-party organizations who worked with the direct recipients of the grants.

The partnership that started it all was the one between IDRC and Global Affairs Canada. CIFSRF was established, designed, and managed for nine years in partnership between two donors who had the desire and foresight to bring together the elements of research (the mandate of IDRC) and development (the mandate of Global Affairs Canada). Together, the two identified and developed strategy documents, work plans, monitoring frameworks, and processes for joint decision making. Project implementation was facilitated at various levels in both organizations by strong collaboration, open communication channels, and sharing of information to ensure smooth operations for the program.

Partnerships played a crucial role in building on different strengths and creating new opportunities and resources to address food security and nutrition. A specific CIFSRF goal was to help partners increase their capacities to generate, disseminate, and scale up research by enhancing team and organizational skills, leveraging new funding, and training graduate students.

At the program level

Research partnerships were shaped by CIFSRF's competitive calls for research proposals. Criteria for these calls were developed with an eye to advancing Southern priorities and local research agendas that would contribute more directly to solving the challenges faced by the poorest countries, and to create equal and mutually beneficial collaborations.

CIFSRF played a key role in establishing and strengthening Canadian–developing country partnerships. The Fund effectively mobilized Canadian expertise, and Canadians are widely recognized as having contributed significantly to the success of projects. Canadian researchers and institutions also benefited from their engagement in the partnerships.

Universalia, 2016

Partnerships in Phase 2 required involvement from at least one Canadian institution and at least one institution from another eligible country.⁹ Involving a business-oriented organization for scaling up was a mandatory criterion in the final call.

Proposals also had to demonstrate

- the roles and responsibilities of each organization and all key individuals, justifying how each organization added value
- representation from multiple disciplines, involving social and natural scientists
- the percentage of professional time commitment by all key team members
- a distributed team leadership structure
- assignment of a project coordinator
- gender balance within the team
- equity in budgets among the organizations

The program further nurtured partnerships by holding meetings that brought all partners together during proposal development and immediately after project approvals. IDRC also strengthened partnerships through capacity-building workshops, bringing multiple project teams together to share and learn on topics that included gender integration in research, communications, scaling up, and monitoring. IDRC program officers worked closely with teams to

encourage collaboration at all levels and to offer support, resources, and advice when needed. An external review found this type of support to be invaluable to the teams.¹⁰

Within projects

The composition of partnerships within projects was dependent on the innovation and the scaling pathway. Given Phase 2’s emphasis on scaling up, a more diverse range of partner organizations was needed than in Phase 1, which focused largely on testing concepts. Private and public sector actors, not-for-profit organizations, and regional and international researchers were added to research partnerships as needed to extend the geographic and institutional reach of the innovations. As in Phase 1, teams engaged farmers and their associations as partners first and foremost.

The complexity of the challenges addressed in the projects demanded high levels of cooperation in teams to integrate methods, data, and concepts from two or more disciplines. Most of CIFSRF’s Phase 2 projects (15 out of 18) built on pre-existing relationships, and 10 of these built on Phase 1 projects. In addition to their long-standing connections, partnerships were strengthened by memoranda of understanding that specified terms of collaboration, steering committees that enhanced their coordination and guided adjustments, project coordinators who kept communications and reporting on track, and regular meetings and open communication between partners.

Results

From 2009 to 2018, 167 organizations were involved in CIFSRF projects (see Figure 1). These were balanced between NGOs (29%), universities (26%), government bodies (23%), private sector firms (19%), and multilateral groups (3%). The majority of research was conducted in the Global South, and developing country partners received the bulk of funding (60%).

These partnerships, which cut across geographic, sectoral, and disciplinary boundaries, generated new skills and knowledge, scientific discoveries, and additional funding for research, and made use of extended networks and connections to scale up innovations.

New capacities for Canadian and Southern partners

Recent analysis by IDRC found evidence that scientific rigour and capacity strengthening are linked.¹¹ In CIFSRF, most projects had capacity-building activities built in from the start, but supplementary activities were added over the life of the projects as needed. Teams said that they gained new skills from the partnerships, particularly in research, project management, scaling up, and ways to inform policy.

For Canadian partners, CIFSRF provided access to international opportunities and the vital knowledge and networks of regional development partners. The projects raised the level and understanding of development issues among Canadian scientists and helped them navigate different cultural contexts. They learned how to adapt research methods to suit unstable field conditions and increased their understanding and appreciation of policy needs in the Global South.

Figure 1: Breakdown of organization types in CIFSRF partnerships (2009–2018)



For developing-country partners, CIFSRF collaborations offered access to world-class expertise in agriculture and nutrition sciences. In some cases, Canadian university partners offered cutting-edge testing facilities, technologies, and experimental techniques that would not have otherwise been available to developing-country research teams.

Collaboration between the University of Guelph, Tamil Nadu Agricultural University (TNAU) in India, and the Industrial Technology Institute (ITI) in Sri Lanka illustrates the two-way dynamics of CIFSRF partnerships. Canadian knowledge of hexanal (a natural extract that prevents fruit spoilage), combined with Indian expertise in nanotechnology applications for fruit packaging, led to the development of a range of sprays, wax dipping, and packaging to extend harvest times and enhance the quality and shelf life of soft fruits to significantly reduce losses for growers.

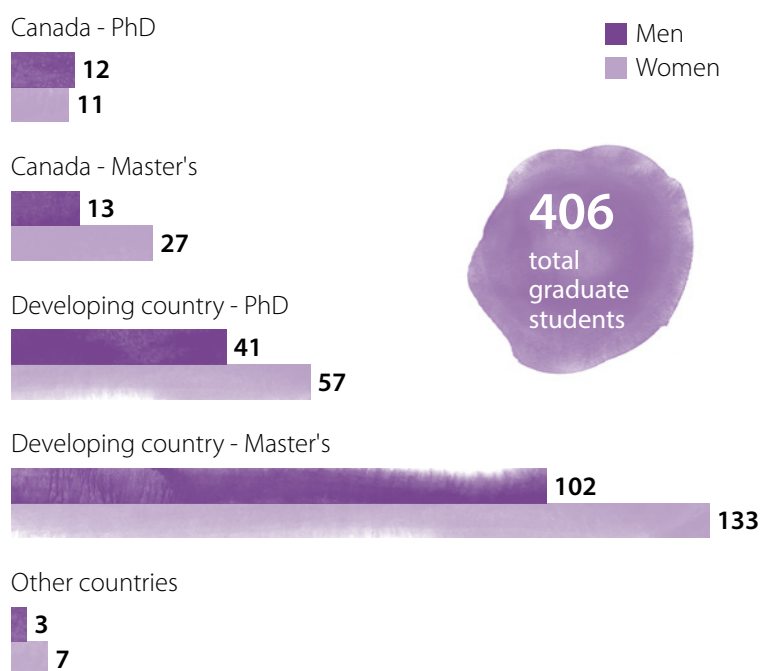
All of the teams benefited from capacity building in terms of equipment and human resources. Younger team members from TNAU and ITI were exposed to first-class laboratories in Guelph and trained in horticulture, post-harvest science, and nanoscience — all valuable to their career growth. With four years of support from CIFSRF, the TNAU team is well positioned to take the lead in nanotechnology in India. ITI is now collaborating with the Institute of Post-Harvest Technology in Sri Lanka to expand the scope of the nanotechnology spray treatment and the Bio-Wax application for use on limes to extend the crop season and reduce post-harvest loss.

Canadians also gained important knowledge from conducting on-the-ground research in developing countries. For example, by collaborating with Kenyan scientists on the development of a vaccine to eradicate contagious bovine pleuropneumonia, researchers from the VIDO-InterVac Centre at the University of Saskatchewan gained insights into the potential methods of control for *Mycoplasma bovis*, a closely related pathogen that causes substantial economic losses for Canadian cattle and bison producers. The Canadian researchers increased their capacity to deal with foreign animal diseases and interact effectively with research and development partners in African countries.

This project enabled Canadian researchers to interact with and learn directly from smallholder farmers in remote Nepal — a unique scientist–farmer partnership that is forever changing the lives of the Canadians involved.

Prof. Manish N. Raizada,
University of Guelph

Figure 2: Graduate students involved in CIFSRF projects (2009–2018)



CIFSRF projects provided extraordinary opportunities for young scientists to gain accreditation and laboratory and field research exposure. Over the program's nine years, over 400 graduate students (58% of them women) were involved in CIFSRF research projects as part of their academic studies (see Figure 2). Projects provided support and training to students to develop their research, write their theses, and contribute to journal publications to advance their careers. Perhaps more importantly, students developed a cross-cultural understanding of how research and development happen.

Additional sources of funding to scale up innovations

Another measure of successful partnerships was their ability to leverage complementary funding. Of the 39 projects supported during both phases of CIFSRF, 20 secured additional funding before their completion. Canadian organizations alone leveraged an additional CA\$40,481,335 in research funding during their CIFSRF projects, equivalent to one-third of the total CIFSRF program funding. This additional funding was vital in enabling teams to continue related research.

Grants came from various sources. For example, the Ontario Ministry of Agriculture, Food and Rural Affairs provided a grant to the University of Guelph for "further discovery and innovation and [to] position Canada as a world leader in agri-food."¹² The University of Toronto received CA\$3.9 million from the Bill and Melinda Gates Foundation to continue its work on double-fortified salt, in addition to the CA\$19 million contributed by the Indian state government of Uttar Pradesh to cover the costs of public distribution.

Funding support from CIFSRF has helped to strengthen the long-standing partnership between the lead partner organizations in soil and agronomy research, and to shape nutrition and food science programs at Hawassa University.

Dr. Sheleme Beyene
Hawassa University

Scientific advances enabled by insights across disciplines

Working across disciplines with a unified vision and common understandings was perhaps the biggest single challenge demanded of research teams — but it is one that paid off with new insights into long-standing challenges. Southern and Canadian researchers involved in Phase 2 projects reflected a wide range of expertise in fields as diverse as soil science, microbiology, plant pathology, crop genetics, biotechnology, participatory plant breeding, vaccinology, aquaculture, rural development, gender and social analysis, nutrition and food science, water and sanitation, public health, business management, economics, microfinance, agribusiness, marketing and communications, data management, and information technology.

By harnessing insights from a range of social and physical sciences, these multidisciplinary partnerships produced a number of scientific advances with practical application in food security and nutrition. Here are just a few:

- West African and Canadian research on soil fertility in the Sahel confirmed that fertilizer micro-dosing could be used on a long-term basis without harming soils.
- A Canadian–Ivorian research team discovered how lethal yellowing, a parasitic coconut disease, is spread in Côte d'Ivoire. They identified the type of phytoplasma (a sub-group of bacteria) that is responsible for the disease as well as the disease vector, a previously unidentified species of leafhopper insect. They developed a new technology for early detection in the field and produced strategies to help farmers manage the spread of the disease before it destroys the country's coconut industry.
- A new bio-sensor developed by Canadian and Nepalese partners gives farmers an affordable and easy way to test soil and plants for nitrogen availability. The bio-sensor can help to reduce the need for synthetic fertilizer and improve farmer livelihoods.



- Several projects made important strides in food fortification, including a stable formulation of salt fortified with iodine and iron that is available to tens of millions of people in India, and a means of fortifying crude sunflower oil with vitamin A that retained beneficial levels through local storage and distribution.
- Canadian technology and expertise was leveraged to bio-fortify pulses in Ethiopia and potatoes in Colombia. Collaborative training and field testing also improved soil management practices.
- Research findings have been published in peer-reviewed journals, including widely read publications such as *World Development*, *Nature*, and *Gender and Development*, and specialized journals such as *American Potato Research*, *Madras Agricultural Journal*, *African Crop Science*, and *Canadian Journal of Phytopathology*.

As of mid-2018, the 39 CIFSRF projects had produced a total of 471 peer-reviewed articles (published or submitted), 72 policy briefs, 87 books or book chapters, 375 theses, and 146 films and videos.

In addition to publishing their results, teams attended regional and international conferences to share and present their findings and engaged regularly with local policymakers throughout the life of the research. This helped to ensure local relevance and brought awareness over issues to the attention of decision makers who have the power to change local policies to improve conditions for their citizens.

▲ A small business owner is supported by CIFSRF to locally fortify unrefined sunflower oil with vitamin A in order to reach rural women and children deficient in vitamin A, Singida, Tanzania.

Connections and knowledge to support different scaling up pathways

The challenge of scaling up in Phase 2 demanded that partnerships reach beyond the usual research connections to encompass other sectoral partners that have the knowledge and connections needed to extend the reach of innovations.

By working with development-oriented NGOs who brought their own development expertise and engagement with communities, researchers were able to ensure greater participation from technology users and involve them in the research process. In some instances, NGOs also offered important policy connections. For example, results from the Scaling up Homestead Food Production project are well situated to influence the next five-year National Strategy for Food Security and Nutrition due to Helen Keller International's extensive nutrition expertise and long-standing relationship with the Cambodian government.

Often government bodies were directly involved in partnerships, and were engaged as important stakeholders to inform or support changes needed in agricultural investment, management practices, or food safety regulations. In many cases, government involvement resulted in amendments to national laws or municipal ordinances, as in Bolivia, where research has helped to inform new national guidelines for sustainable fisheries (see page 65).

Private sector companies, microcredit facilities, and NGOs with expertise in marketing and social enterprise played an important role in scaling up through market-based pathways. In Colombia, a partnership with the private plant-breeding company Agroidea was key to scaling up the cultivation of new potato varieties. It produced elite potato seed tubers of the new cultivars and sold them directly to potato producers.

Best practices

In managing CIFSRF, our role has extended beyond simply funding research. We engaged with projects and partnerships throughout the process to support their priorities and help them connect to other researchers, businesspeople, and policymakers to increase the impact of their research.

Insights drawn from our experience suggest the following measures to nurture productive partnerships.

Start by developing a common vision to address a shared challenge

A shared vision is key to successful collaboration. CIFSRF supported the development of a shared vision from the earliest stages of research design. Face-to-face meetings held before approvals brought partners together to develop a common understanding of the scope and aims of scaling up research and the importance of developing partnerships with organizations that have the skills and connections to support scale-up.

It is also essential to engage with farmers, businesses, policymakers, and all other stakeholders at the early stages of a project to ensure the wide adoption of appropriate and relevant innovations. Inception workshops served to publicly launch the projects and connect researchers with a broader range of stakeholders. Joint technical reporting throughout projects brought partners together to discuss findings, share analysis and authorship, build leadership, and improve management capacity.

The challenge for CIFSRF partnerships was less about aligning a North–South agenda and more about coordinating the varied approaches and interests of academics in different disciplines, NGOs, policymakers, and private sector partners. This demanded a shared understanding of the partnership criteria, mutual commitment and trust, and respect for cultural norms and values.

A winning partnership for scaling double-fortified salt throughout India

Of all the ingredients that shaped the successful scale-up of double-fortified salt (DFS) in India, perhaps the most essential was the solid collaboration between Canadian and Indian research institutes, the private sector, three state governments, and public and private donors.

To counter iodine deficiencies that could lead to stunted physical and mental growth, salt fortified with iodine has been consumed by billions of people for decades. With more than half of women and preschool children in India suffering from anemia, it follows that fortifying salt with iron would also have a tremendous impact on public health.

The University of Toronto's breakthrough development of a stable and cost-effective salt fortified with both iodine and iron built on a long-term collaboration to fortify food staples between M.G. Venkatesh Mannar, a former president of the Micronutrient Initiative, and Professor Levente Diosady of the University of Toronto. Given salt's reactive qualities, the iron is first microencapsulated and then added to iodized salt to form a stable product indistinguishable from regular salt.

The St. John's Research Institute in Bangalore tested the salt for stability and efficacy. JVS Foods Pvt. Ltd., an Indian company that pioneered the production of micronutrient-fortified foods for public feeding programs, produced the premix in

local mills. A social market research firm, Barometer Research, tested consumer acceptance and effective marketing.

Tata Trusts, an Indian philanthropy group linked to the Tata group of companies, contributed CA\$600,000 in funding and worked with the state of Uttar Pradesh to establish procurement and distribution systems in 10 districts. Following initial rollout in Uttar Pradesh, the states of Madhya Pradesh and Jharkhand procured the DFS formulation for distribution through their public systems.

To ensure mass distribution and to reach those most likely to suffer malnutrition, the Canadian researchers licensed the intellectual property behind DFS to JVS Foods on a no-cost basis for sale to salt producers designated by government authorities. **As of mid-2018, some 50 million Indians in three states were consuming salt fortified with iron and iodine that was distributed through public systems.**

The success of this project stems, without question, from the quality and duration of the partnerships at its core. Team leaders exhibited not only research excellence and effective management, but a passionate commitment to realizing their shared vision of improving the nutrition of India's poorest citizens.

Have at least one strong leader per organization

Having at least one strong leader per organization helped to drive and inspire the teams, facilitate dialogue, and develop networks to improve the reach and impact of research.

CIFSRF screened proposals for signs of strong leadership. Many project leads had long and distinguished careers — several were Canadian research chairs in their field, one was a Member of the Order of Canada, and many others had been recognized through career achievement awards. Leadership was also developed over the course of projects by capacity building in a number of areas.

Each project had a dedicated coordinator to ensure that projects remained on track and well documented. This role absorbed some of the managerial burden, enabling team leaders to focus on the big picture — making the connections needed to drive innovation and scaling.

Allow and expect flexibility within partnerships

Each partner brought a unique set of skills, knowledge, and connections to advance the development or scale-up of innovations. Roles changed over the course of projects; in some instances, new partners were added and others were dropped.

A few projects experienced the loss of a key team member. While this was obviously a setback, it allowed junior researchers to take on more responsibility. Canadian researchers, who often enabled access to advanced experimental techniques or facilities to develop innovations, increasingly took a back seat as projects evolved to achieve impact at scale. Third parties with specific skills such as gender or marketing expertise were also brought on board.

Teams were allowed to make changes along the way, including no-cost time extensions and second phases where possible. This flexibility strengthened their capacity to build on earlier pilot work towards the complexities of scaling up.

Support equity between partners through openness and transparency

Openness and transparency are necessary from the beginning of the research process to ensure partner equity. This includes sharing budgets throughout a project's lifecycle, providing access to information, and establishing agreements on intellectual property, patents, and co-authorship of publications. Most project teams met monthly via Skype, with at least one annual face-to-face meeting for the entire team and use of document-sharing tools to facilitate joint work. Some partnerships also benefited from internal MOUs to clarify roles, responsibilities, and expectations.

CIFSRF laid out expectations for partner equity from the start. This included equitable budget distribution that accurately reflected the roles and responsibilities of each organization. Budgets were agreed upon by the project leaders from all applicant organizations, and budget flexibility enabled teams to respond to changing circumstances.

Factor in the time and space needed for partnership building

Partners built up knowledge on ways of working with different partners only by actually working with them. This required time and space where academics, NGOs, government, and private sector participants could connect for knowledge exchange and learning to happen. These spaces fostered greater collaboration by recognizing diversity in skills and perspectives, identifying shared areas of interest, developing a common language and shared understanding, and allowing for the exchange of ideas. Capacity building took place at all levels, from project leadership and management in working with large multi-sector projects and cross-learning with laboratory and field staff to training of students and beneficiaries. Capacity building is an equally important indicator of success of the impact of the research, but is sometimes undervalued.

Partnerships take time — especially complex international ones involving many different types of organizations. Neither teams nor donors should underestimate the time needed to build trust, forge mutual understanding, and clarify goals, roles, and

responsibilities — all while factoring in differences in time zones. For the complex scaling up that CIFSRF aimed for, at least one year was needed for partnership building, but projects that built on previous research partnerships enjoyed a head start.

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New developments on the nutritional aspects of chickpeas. The University of Hawassa is trying to improve the quality of chickpeas in Ethiopia. On the right, Mr. Molla Assefa, Butajira, Ethiopia.

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- 10 Universal Management Group. 2016. CIFSRF External Evaluation of Phase 1 Final and Phase 2 Mid-term. <http://hdl.handle.net/10625/56897>.
- 11 Lebel, J. and McLean, R. 2018. A better measure of research from the global south. *Nature*. Published online: July 4, 2018. <https://www.nature.com/articles/d41586-018-05581-4>.
- 12 <https://news.uoguelph.ca/2018/02/omafr-u-of-g-agreement>.



**The road
ahead**



Availability, access, use, and stability. These four key pillars were the focus of the Canadian International Food Security Research Fund (CIFSRF)'s approach to global food security, and as a result up to 78 million smallholder farmers and consumers in the Global South benefited from evidence-based food security innovations that were generated from 2009 to 2018. These wide-ranging innovations included scientific breakthroughs and technological advancements in food production, post-harvest losses, and livestock vaccines, in addition to improved agricultural practices, techniques, products, and tools.

We learned from CIFSRF that for food security innovations to be timely, relevant, and useful, they must respond to the needs of people and be informed by researchers, development practitioners, and policymakers who consistently work with and learn from farmers and community members. Achieving impact at scale requires research for development partnerships combining multidisciplinary and multi-sectoral teams that complement the research objectives and ensure a holistic approach to addressing complex food security issues.

CIFSRF has influenced the research agenda and generated outcomes that span beyond the results of its projects. Two projects on livestock vaccines led to the launch of a six-year, CA\$57 million research initiative on livestock vaccines co-funded by Global Affairs Canada, the Bill and Melinda Gates

Foundation, and IDRC (2016–2022). The CIFSRF structure was also replicated as the model for a nine-year, CA\$35 million research program on food and nutrition security in East and Southern Africa co-funded by IDRC and the Australian Centre for International Agricultural Research (2013–2022). In this way, CIFSRF has helped to leverage much larger investments for agricultural research.

Governments, international actors, civil society, and researchers are committed to ending all forms of hunger and malnutrition by 2030. However, despite concerted efforts over the last decade, the number of people affected by food insecurity has actually increased for the first time in almost 10 years. In 2017, 821 million people were considered food insecure compared to 777 million just two years before¹; that is 821 million too many.

Addressing food insecurity and promoting inclusive development remain key priorities for the international community; however, the contexts influencing food insecurity are constantly evolving. Complex and competing influences such as climate change and conflicts require researchers to constantly adapt. Malnutrition, for example, can face contrasting challenges: globally, while nearly 25% of children suffer from stunted growth because of malnutrition, almost 2 billion adults were overweight in 2017.²

As the former secretary-general of the United Nations Kofi Annan stated, "Despite the rapid growth in the services sector, agriculture still accounts for more than



a third of Africa's GDP. Africa is urbanizing rapidly, but agriculture still employs two-thirds of the workforce. Evidence has shown that growth in agriculture is up to 11 times more effective in reducing poverty than growth in any other sector. If we want to end poverty and hunger in Africa by 2030, agriculture needs to be right at the heart of the strategy.³ Yet, millions of women and youth have no or little access to technology, markets, and productive resources on which they can build. More must be done to close the gap on the limited understanding of how different agricultural models can impact the capacity of youth and women to engage in and benefit from agriculture in different agro-ecological and social contexts in the Global South.

Women are increasingly claiming their space in agriculture, and their voices are being heard now more than ever. They make up more than 50% of the agricultural labour force in East Asia and sub-Saharan Africa, and 20% in Latin America.⁴ Governments, donor agencies, civil society, and philanthropic foundations are integrating and developing new gender strategies that respond to the needs of women in agriculture and food systems. Today we are in a position to identify the hotspots of hunger and gender inequality and can target our interventions to ensure that women and men benefit equally from research for development.

It's time to rethink the way we respond to knowledge gaps.

- We need to move away from the idea that identifying women's contributions to agriculture is sufficient, and complement this approach by a focus on how food and agricultural systems can collectively contribute to the process of women's empowerment.

- We envision a future of gender-transformative food systems anchored in a broader understanding of complex family interactions that shape gender relations. Food systems should be inclusive, be sustainable, be resilient to change, and eliminate gender inequalities.
- We cannot achieve a world without hunger unless we transform the current food systems; this transformation must go hand in hand with the transformation of the lives of women and men.
- We must address the structural impediments to gender equality and the achievement of women's rights, and must continue to link research and development to ensure that new innovations are meaningful and translate into real and sustainable changes for the largest number of people.

Investments in research for development — for example, the findings in new technologies, new seed varieties, new food processing, and new markets — are still required for the road ahead. These efforts must be complemented by a parallel attention to the new social dynamics generated by present forms of globalization, urbanization, migration, and conflicts around the world. We must continue to promote ways of doing research that connect women's groups, youth, experts, markets, and policymakers to generate lasting solutions to food and nutrition security. Building on CIFSRF's lessons, we must inform the next generation of research so that it contributes to more inclusive and resilient food systems that will be necessary to ensure that the world can feed 9 billion people by 2030.

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1 FAO, IFAD, UNICEF, WFP and WHO. 2018. The State of Food Security and Nutrition in the World. Building climate resilience for food security and nutrition. Rome: Food and Agriculture Organization of the United Nations.

2 WHO. 2018. Obesity and overweight fact sheet. World Health Organization.

3 Annan, K. 2017. Building an Africa free from hunger and poverty. Opinion. In Poverty & Development, Al Jazeera.

4 FAO. 2011. Women in Agriculture: Closing the gender gap for development. Rome: Food and Agriculture Organization of the United Nations.

CIFSRF Phase 1 (2009–2013) projects

Development of a Vaccine for Eradicating Contagious Bovine Pleuropneumonia in Africa (\$3.7 M)¹

Enhanced Preservation of Fruits in South Asia (\$2.3 M)

Food Security, Fisheries and Aquaculture in the Bolivian Amazon (\$2.5 M)

From Farm To Fork: Improving Nutrition in the Caribbean (\$5 M)

Improving Food Security in the Highlands of Ethiopia through Improved and Sustainable Agricultural Productivity and Human Nutrition (\$1 M)

Improving Nutrition in Ethiopia through Plant Breeding and Soil Management (\$1.6 M)

Improving Potato Production for Increased Food Security of Indigenous Communities in Colombia (\$2.9 M)

Increasing Millet Production in South Asia (\$3.5 M)

Integrated Crop and Goat Breeding in Tanzania (\$1.7 M)

Integrated Nutrient and Water Management for Sustainable Food Production in the Sahel (\$1.8 M)

Integrating Agroforestry and Sheep Feed in Mali (\$1.8 M)

Organic Farming in the Peruvian Andes (\$5 M)

Promoting Adoption of Chickpea Technologies in Southern Ethiopia (\$0.4M)

Promoting Rural Income from Sustainable Aquaculture through Social Learning in Sri Lanka (\$1 M)

Reducing Malnutrition in India's Agri-Biodiversity Hotspots (\$4.9 M)

Scaling Up Agricultural Innovations in Kenya (\$4.3 M)

Scaling Up Sustainable Aquaculture Development in Sri Lanka (\$0.4 M)

Small-Scale Aquaculture to Strengthen Food Security in Cambodia (\$3 M)

Sustainable Production of Underutilized Vegetables to Enhance Rural Food Security (\$2.9 M)

Traditional Grains Boost Nutrition in Rural India (\$1 M)

Vaccines to Combat Livestock Diseases in Sub-Saharan Africa (\$3.1 M)

Michael Matambi, the Crop Officer with the Mbeya District Council, points out the problems bugs can cause to soybeans, Mbeya, Mapogolo, Tanzania.



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¹ All figures are in Canadian dollars for project budget. Amounts have been rounded to the nearest hundred thousand.

CIFSRF Phase 2 (2013–2018) projects

Achieving Impact at Scale through ICT-Enabled Extension Services in Ghana (\$1.5 M)²

Amazon Fish for Food (\$5 M)

Development of a Subunit Vaccine for Contagious Bovine Pleuropneumonia in Africa (\$4.9 M)

Enhanced Preservation of Fruits Using Nanotechnology (\$4.2 M)

Farm Shop: Scaling Access to Agricultural Inputs in Kenya (\$1.5 M)

Fermented Food for Life (\$1.5 M)

Fighting Lethal Yellowing Disease for Coconut Farmers (\$2.6 M)

Nepal Terrace Farmers and Sustainable Agriculture Kits (\$2.2 M)

Novel Livestock Vaccines for Viral Diseases in Africa toward Improved Food Security (\$5 M)

Promoting Locally Fortified Sunflower Oil Using E-Vouchers (\$4.2 M)

Scale Up Of Homestead Food Production for Improved Nutrition in Cambodia (\$4.5 M)

Scaling Up Fertilizer Micro-Dosing and Indigenous Vegetable Production and Utilization in West Africa (\$4.5 M)

Scaling Up Improved Legume Technologies in Tanzania (\$1.5 M)

Scaling Up Pulse Innovations for Food and Nutrition Security in Southern Ethiopia (\$3.9 M)

Scaling Up Small Millet Post-Harvest and Nutritious Food Products (\$1.5 M)

Scaling Up Small-Scale Food Processing for Therapeutic and Complementary Foods for Children in Vietnam (\$1.2 M)

Scaling Up the Production and Distribution of Double-Fortified Salt in India (\$1.5 M)

Scaling Up the Production of More Nutritious Yellow Potatoes in Colombia (\$1.5 M)

2 All figures are in Canadian dollars for project budget. Amounts have been rounded to the nearest hundred thousand.







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