Canadian International Food Security Research Fund

Understanding the CIFSRF Phase Two portfolio's overall contribution to food security

July 2018

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Acknowledgements and disclaimer

We thank the many people who have helped provide information from which this paper has been compiled. Much was learned from visiting six of the CIFSRF projects where participants, field staff of partners, government officers, and other stakeholders patiently answered the many questions we had. Canadian research leaders gave us the benefit of their considerable insights when interviewed. IDRC desk officers and programme managers gave us copious briefings on particular projects and the programme as a whole, and commented on drafts of reports on the six in-depth studies.

Nevertheless, the authors of this report are solely responsible for the opinions and ideas in this synthesis, including any errors and omissions. The views expressed do not necessarily reflect those of IDRC or ODI.

Abbreviations

BCC	Behaviour change Communications
CIFSRF	Canadian International Food Security Research Fund
FAO	Food & Agriculture Organization of the United Nations
FNS	Food and nutrition security
IDRC	International Development Research Centre
LIBIRD	Local Initiatives for Biodiversity, Research and Development — Nepali NGO
R4D	Research for Development

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Summary

Purpose of this paper

The Canadian International Food Security Research Fund (CIFSRF), a programme of Canada's International Development Research Centre (IDRC), was designed to address global problems of food and nutritional insecurity through applied, collaborative, results-oriented research. Phase 1 (2009–2014) focused on testing innovations, while Phase 2 (2013–2018) aimed to test both scaling up methods and mechanisms, as well as to scale up practical solutions to increase food production, raise income for farming families, and improve nutrition.

This paper synthesises the findings from a contribution analysis of the CIFSRF Phase 2 portfolio of research projects, commissioned primarily to generate learning about the programme for the benefit of IDRC. The contribution analysis aimed to:

- evaluate results of the projects and assess their impact, observed or potential, on food security;
- consider to what extent the CIFSRF projects have contributed to observed and potential results and impacts; and,
- consider to what extent the activities and gains initiated are likely to be sustained and scaled up.

This paper draws on contribution analyses of six CIFSRF Phase 2 projects, intentionally selected as projects likely to show significant and revealing results, to which field visits lasting two weeks each were made: The remaining twelve studies in Phase 2 were more briefly reviewed, drawing largely on the project approval document and recent technical reports.

Findings

Nature and relevance

The 18 projects of CIFSRF Phase 2 had diverse strategies and activities to promote food security, addressing one or more of the four dimensions of food security — food availability, access, utilisation, and stability. The projects clustered into groups:

- Nine were concerned with growing nutritious crops and fish, primarily for home consumption by the participants, intended to reduce dietary deficits of protein and micro-nutrients;
- Five worked with small-scale food processors to produce foods with added protein, vitamin, minerals and probiotics; and,
- Four were concerned with avoiding losses of crops and livestock to disease and spoilage. These made more food available, and raised producer incomes thereby potentially increasing access to nutritious food.

Project teams targeted participants by location, choosing rural areas where most households were on low incomes; subject to the area having the conditions to test innovations, being accessible, and being somewhere where the local partner had experience. Within communities, projects worked with a range of participants, without further trying to select those on the lowest incomes or otherwise disadvantaged.

Results and impacts

The projects had been implemented with considerable dedication by the field teams and their leaders. The volume of activity, the number of groups of participants reached, the care with which activities had been carried out, and the willingness to adapt and change things when obstacles arose, were highly impressive.

Consequently, from the evidence available by May 2018, most activities in most projects had achieved what was intended and possible by that time — even if, for some activities, the full results and impacts remained to be seen.

Project teams had, for the most part, also successfully engaged with policy-makers. Mainly this was to inform them, to coordinate field activities with government services and programmes, and to raise the profile of the issues addressed by the projects and potential of the innovations developed. Only a few projects depended on

policy changes for success. In such cases, necessary changes had been achieved; with the part exception of innovations that required approval by regulators, processes that proved lengthy and were not complete by May 2018. Nevertheless, the prospects of approval were favourable.

Sustaining and scaling up CIFSRF initiatives

If scaling up is taken to mean operating across most of the territory for which an innovation is appropriate, through agencies that intend to be longstanding, rather than temporary projects, then during Phase 2 most projects had only taken the first few steps to scale up. For the most part, they had advanced from proving a concept to developing a working model: a necessary, but not sufficient, condition for scaling up.

What will allow the innovations and activities started under CIFRSF to be sustained and scaled up to reach their potential application?

Most innovations promoted by CIFSRF projects resulted in gain to private actors, be they households, farms or firms. It is thus likely that project participants, and those input suppliers and traders they engage with, will have sufficient interest to sustain activity. This applies above all to innovations embodied in tools and other farm inputs that can be supplied privately.

Other agricultural innovations not so embodied conferred private gains, but depended on messages that are public: intercropping, for example. Such innovations will require public extension to sustain and scale up. Indeed, some public extension may be needed to support all agricultural innovations to confront challenges such as pest and disease attacks.

Just a few project activities produced pure public goods and services, and hence will rely on public services to sustain them: nutrition education is the main example.

Very few activities depended on collective action, the most prominent example being the management of river fisheries in the Bolivian Amazon.

Three projects required approval of their innovations from the regulators. In some cases, approval had been delayed, but will probably eventually be granted.

Discussion

What made for success in implementation?

Two factors seemingly explained much of the considerable success of the CIFSRF portfolio. performance. One was the sheer quality of the staff in the teams, both local partners and Canadians. All grades of staff met possessed well-above-average experience, formal qualifications, or both; and were enthusiastic and committed to their projects. The other factor was the support and encouragement given by IDRC staff who engaged closely with the work of the project teams, helping facilitate whatever course corrections or additional activities proved necessary.

The management of most formal organisations emphasises formal structures, systems and roles; rather than the persons who occupy those posts at any given time. Yet when it comes to innovations, the skills and dedication of individuals and teams matters. IDRC did well to select, support and encourage the project teams of CIFSRF.

A qualification applies here. It was clear from interviews with project staff that many had worked far longer and harder on these projects than was funded. While few research funders could promise grants at the outset sufficient to cover most of what typically gets done in successful research, it implies that funders should subsequently be prepared to authorise additional spending when justified in promising research.

Could the portfolio have been more relevant to food and nutrition security, or better targeted to the disadvantaged?

Impressive as CIFSRF Phase 2 has been, could it have been better? Could the projects have been more relevant, in content and participants?

The projects had much to commend them. They addressed relevant issues, focusing mainly on increasing

food availability in pursuit of remedying dietary deficits in minerals, protein and vitamins.

Four aspects of the portfolio invite reflection. One was the quite liberal approach to food security taken by successful applicants for funding. A few projects were not that closely focused on food and nutrition security, such as the two livestock vaccines and the coconut disease project. While their success will boost food production, so too would almost any agricultural development project.

The second was that innovation was almost always focused on production, whether on farms, or in processing plants. No projects focused on innovations to address food security utilisation issues of child care, primary health, diet and hygiene. Around half the CIFSRF projects, to their credit, included nutrition education as complements to their focus on agricultural production; but as complements, using known technology, not as innovations.

A third was the disciplinary leadership. Most of the project leaders from both Canada and the South came from a natural science or technology background, rather than being social scientists. That courted the danger of proposals being developed as technical solutions seeking problems, rather than vice versa. In the event, that risk was very considerably mitigated by the way in which project teams developed their projects, widening their scope to address problems seen in the field, regardless of whether initially-favoured technologies were likely to be part of the answer.

A fourth and final observation concerns project participants. The projects worked with people on low incomes, more than half of them women, although not necessarily the poorest and most disadvantaged. Most projects targeted primarily by location of activities, looking for those where most people were on low incomes. Once locations were chosen, however, little further was done to target by social characteristics, other than to try and work with at least as many women producers as men.

It would, however, have been difficult to work more with disadvantaged groups within the communities chosen, and still have equally effective projects. To participate in research-for-development (R4D) projects, households needed to have some resources — a little land, some labour, the ability take time to participate in groups and project activities; resources that many disadvantaged persons would not have. More pertinent, it is hard and risky for external projects to select participants within communities, unless they know this has general consent from members of the village, and support — or at least acquiescence — from leaders. Projects that aim to raise production, as most of the CIFSRF projects did, tend to be seen as a common resource, that should open to all in the community to participate.

What mattered more was that innovations were accessible to those with the least means in the communities. The projects that included multiple innovations, with Nepal terrace farming the outstanding case, had messages for almost all in the communities in which they worked.

These considerations lead to the wider question of the degree of innovation promoted by CIFSRF projects. Three projects were particularly ambitious in their technical focus: one investigating applications of hexanal to fruit spoilage, and the two projects to develop heat-stable vaccines for livestock in Africa. If these are successful, as seems likely, the potential gains could well be very high indeed. If so, then should IDRC have funded more of these technically ambitious projects, and fewer of the less ambitious ones?

The innovations promoted by the different projects were diverse in their technical depth, in the range of innovations, and in the social and institutional changes necessary to facilitate adoption. More than half the projects — and most of those producing nutritious crops — dealt in innovations that were low to moderate in their technical depth. To some extent, that traded off against breadth of innovation. For projects promoting production of nutritious crops, this made sense. Incremental changes to farming systems are more accessible to all farmers,

especially those with few resources, since adopters do not have to make challenging changes or to incur significant risks. Offering a range of innovations, moreover, respects the differences in resources, abilities and preferences found within groups of farmers.

The technical and social requirements of the innovations were inversely correlated. That too was probably wise: to attempt changes in both techniques and social organisation at the same time might have been too much for most participants.

With considerable diversity of innovation across the portfolio, it is likely that the conditions for sustainability and the prospects for scaling up are similarly diverse. It also suggests that it may be difficult to identify general lessons from the portfolio.

Can innovative models be trimmed to sustain and scale them up?

The challenge of sustaining and scaling up for R4D is to make the transition from piloting, when considerable time of unusually talented and committed people are devoted to innovations in a limited area, to larger-scale operations when activities must proceed with less support. To scale up, then, economies to working models must be made.

That means assessing which parts of the pilot have been critical to success, and which have been useful, but not essential, complements. Economising on resources, however, may entail some loss of effectiveness. The art is thus to make operations economical, while still delivering most of the potential benefits.

Documenting experiences from pilot phases to assess the necessary core would provide better guidance for where such economies can be made. While CIFSRF project teams have documented much of their experience, they have not necessarily systematically identified what is essential to their working models.

Scope for more economic and financial analysis may exist. Since most innovations were designed to be carried out by farming households, or by small businesses, simple analyses of costs and returns, benefit-cost ratios, and returns to labour and capital would be useful. Further analysis could then test the scope for economies, while retaining attractive returns.

Lessons learned

Regarding implementation of R4D projects:

1. For the success of R4D projects, **people matter.** CIFSRF has benefited from having highly effective partnerships and field teams, largely owing to the people who led and participated in project teams. Leaders and their teams need to be creative and flexible, resourceful and determined to operate learning processes successfully. For organisations funding research, these criteria should be explicitly sought among applicants.
2. The requirements of some innovations for **approval by regulatory agencies** delayed their dissemination. Although the necessary tests and procedures take time, and may be hard to start before the innovation has been fully developed, where possible such procedures need to be started as soon as possible. The IDRC team is now well aware of this.

For sustainability and scaling up:

3. **Information can be pivotal**. Private incentives to innovate only apply if farmers, food processors, and those who work with them have reliable and convincing information about the innovations and how to make use of them. Market-led rural innovation requires plenty of information: some may be provided through dealer demonstrations and advice, instruction manuals and advertising; but public information can support this with impartial advice.

   For activities that require public services, convincing governments and donors to scale up pilots requires reports and evaluations that convince.

   Collective action can be facilitated by information about models that have worked in other places, and about the processes that led to success — and about what not to do.

4. Pilot R4D projects thus need to generate **reports and briefs** on what was done, achieved and how — together with what was necessary and critical to generate benefits, and what was not. Simple economic analyses of innovations, such as gross margins of enterprises, would be valuable.

5. **Time is needed** to develop working models fit for replication. While pilots can generate interesting and valuable results within two or three years of operation, refining these into working models that can operate at scale usually takes longer: a decade may be necessary. This particularly applies to agriculture which depends heavily on natural systems, vulnerable to external shocks: bad weather, for example, can invalidate a season's work.

   The lengthy genesis of working models presents a dilemma for most donors, who are often reluctant to commit to more than five years of funding. Ways may be found to work within these limits, perhaps by considering how and when different activities piloted can be scaled up; to which answers may differ considerably by component.

   For example, innovations that convey clear private gains using techniques that are conceptually and operationally familiar to users, and probably embodied in a concrete product — think, for example, of a millet thresher, may require little further support once the innovation has been developed. On the other hand, innovations that are public goods, conceptually and operationally novel — for example, of integrated pest management — may need plenty of support before the innovation convinces farmers, agricultural advisers, senior civil servants and ministers, and so on.

   Funds and support might then be programmed accordingly, leading to assistance tapering earlier for some items than others, and allowing those that need more time to get the necessary longer-term support.

1. Introduction

The Canadian International Food Security Research Fund (CIFSRF) was designed to address global problems of food and nutritional insecurity through applied, collaborative, results-oriented research.

CIFSRF is a program of Canada's International Development Research Centre (IDRC) undertaken with the financial support of the Government of Canada, provided through Global Affairs Canada. Phase 1 (2009–2014) focused on testing innovations, while Phase 2 (2013–2018) aims to test both scaling up methods and mechanisms, as well as to scale up practical solutions to increase food production, raise income for farming families, and improve nutrition. The emphasis in Phase 2 was to harness the best of the private, public and not-for-profit sectors to expand CIFSRF's research portfolio so innovations reach more people and have a greater impact globally to improve food security.

This paper synthesises the findings from a contribution analysis of the CIFSRF Phase 2 portfolio of research projects, commissioned primarily to generate learning about the programme for the benefit of IDRC. The contribution analysis more specifically aimed to:

- evaluate results of the projects and assess their impact, observed or potential, on food security;
- consider to what extent the CIFSRF projects have contributed to observed and potential results and impacts; and,
- consider to what extent the activities and gains initiated are likely to be sustained and scaled up.

This paper draws on contribution analyses of six CIFSRF Phase 2 projects to which field visits lasting two weeks each were made: Cambodia homestead gardens; Colombia potatoes; Ethiopia pulses; India small millets; Nepal terrace farming; and Tanzania fortified sunflower oil.[1] These were intentionally selected as projects likely to show significant and revealing results.

The remaining twelve studies in Phase 2 were more briefly reviewed, drawing largely on the project approval document and recent technical reports.

Most of the data collection for this review was carried out between August and December 2017: before most of the projects were concluded, and before final technical reports and any internal evaluations of the individual projects had been drafted. Data from the final technical reports that were available by May 2018 were also considered.

The rest of this paper is structured as follows.

To introduce the portfolio and set in context, the next section (2) considers the relevance and nature of the projects. Because the projects are quite heterogenous, this section groups the 18 projects in three clusters.

Section 3 deals with the critical question of the contribution made by the CIFSRF projects. It looks at the results and impacts evident and likely. This includes considerations of the effectiveness of the research partnerships between Canadian research institutions and their developing country partners, and of policy influence.

Section 4 considers the sustainability of the projects and the prospects for scaling them up.

The final Section 5 draws conclusions, discusses the implications of the more significant findings, and records some of the lessons from this review.

[1] Most of the projects have lengthy titles. In this paper they have been referred to by much-abbreviated titles that nevertheless should be self-evident. The list of titles and the abbreviations adopted can be seen at Appendix A.

2. The nature and relevance of the CIFSRF Phase 2 portfolio

2.1 The nature of the programme

2.1.1 What did CISRF projects aim to do?

The goal of CIFSRF is to achieve:

> Increased environmentally sustainable food security for the most food insecure: including women, girls, women subsistence farmers, men, and boys in targeted developing countries and regions.
>
> [From the programme theory]

This was to be achieved by forming partnerships between Canadian researchers and partners in developing countries, that would lead to applied research relevant to food and nutrition security, carried out in action-research — research for development (R4D) — projects addressing issues in specific contexts, enhanced by using the results for policy influence.

During the lifetime of the Phase 2 portfolio it is to be expected that intermediate outcomes, or results, would be observable; with some of the realisation of the goal, or impacts, to be seen after the projects conclude, given the time necessary for results to translate into impacts.

2.1.2 What might one expect CIFSRF projects to do?

CIFSRF is about food security, commonly defined as:

> Food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. [FAO 1996]

A much-used framework for thinking about food security (FAO 2008) then proposes that individuals — other levels of food security exist[2] — will be food secure when four conditions are met. One, that sufficient food is physically **available.** Two, that individuals have **access** to it. That access may be, for those in farming households, through direct production, or for others through having the economic means to buy food, or through being entitled to a transfer of food from family, friends, charity or government. Three, that access and availability should be **reliable and stable**. Not only should individuals' access to available food not vary significantly by season and year, but also they should feel secure of access to food, free from anxiety that they will go hungry at some time or other.

Four, that the food be well **utilised**, which includes the processes that lie between access to food and translating this into adequate nutrition: how food is prepared, the health of those eating, and for infants, their care and feeding. This condition links food security to nutrition. The processes involved are sufficiently complicated that nutritionists have adopted additional frameworks to conceptualise the processes. (Box 2A)

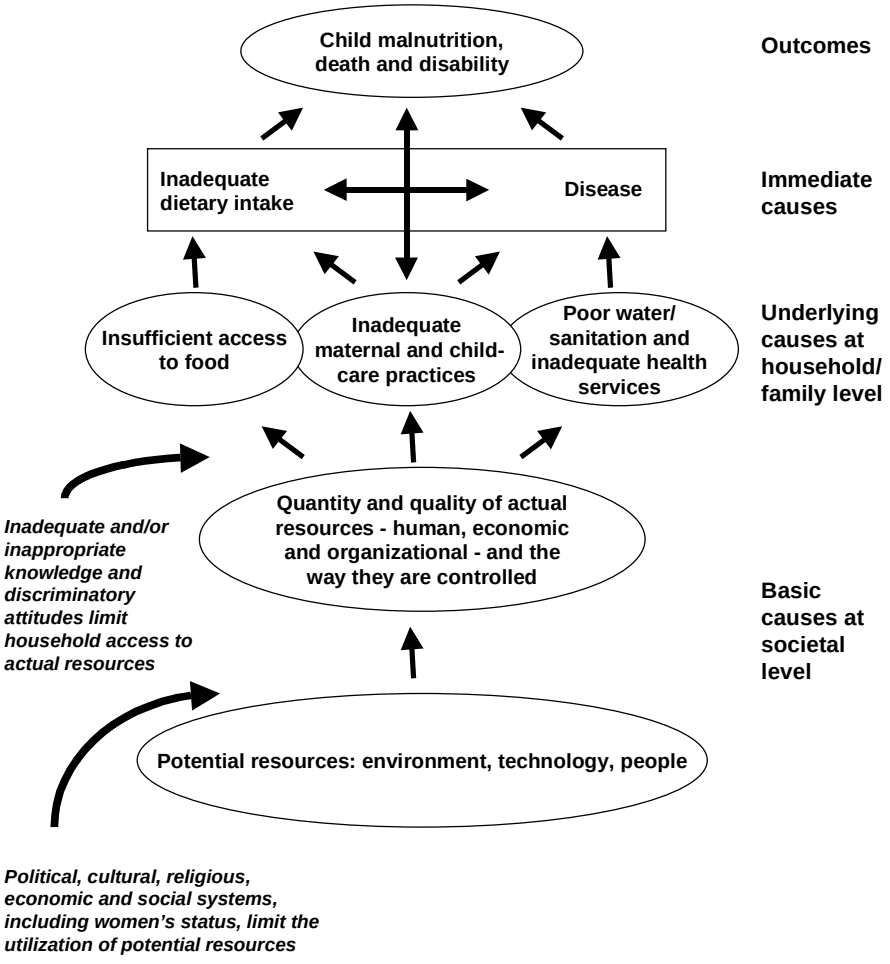
From this point on, the argument will refer to food **and nutrition** security; since by far the most important reason to be food secure is to ensure good nutrition.

[2] Households, communities and nations may also be seen as food secure. The individual level is however the most commonly considered, and measured, because the nutritional outcomes of food insecurity arise in individuals (Box 2A).

Box 2A From food security to nutrition

The causes of child malnutrition, mortality and disability, may be seen through a framework that has been widely used and adapted since the early 1990s.

Figure 2.1 Causes of child malnutrition



Source: The State of the World's Children, reproduced in Pelletier 2002

Child malnutrition has two immediate determinants: inadequate diet and disease. These in turn derive from insufficient access to food, inadequate child care, and poor water, sanitation and health services. Behind these lie the political, economic and social reasons that govern how food and public services are produced and provided, and how they are distributed.

Nutrition thus results from multiple factors interacting in potentially complex systems.

Hence it may be expected that CIFSRF projects would address one or more of the four dimensions of food security. Since the primary focus of CIFSRF is on people on low incomes in rural areas, many of them engaged in agriculture and fishing, then the links between agriculture as one of the main activities of the household and food and nutrition security are relevant. At least seven such links have been identified (after Gillespie et al. 2012), as follows:

1. Agriculture grows food and thus makes food available. It helps if the food grown on the farm is sufficiently diverse and nutritious to include all the elements of a healthy diet — energy, protein, vitamins and minerals;
2. Increased food supplies tend to push down the prices of food in local markets, thereby improving the entitlement and access to food by people with limited incomes;
3. Agriculture provides incomes to farmers and those working the land as labourers, incomes that allow access to food in markets.

   This is conditioned by the extent to which income is spent on food, especially higher value foods, rich in vitamins and minerals, as well as on health, water and sanitation — all factors that may affect nutrition of household members and especially infants. Women's control over income matters here, since women tend to spend more on the household and their children than men do (World Bank 2008);
4. Increased agricultural output usually has multiplier effects, creating additional activity in supply chains, as well as in the local rural economy when farmers and labourers spend earnings on locally-produced goods and services. The additional employment and earnings then allows others to improve their food and nutrition security.

In addition, in some circumstances the following may also apply:

5. The amount of farm work that women have to do may affect the ability of mothers to take care of children, including feeding them;
6. Heavy labour on farms may create high demands for energy that cannot be met from limited access to food; and,
7. Agriculture may expose those working in the fields to hazards from accidents and exposure to crop chemicals, zoonoses and disease vectors fostered by agriculture — such as mosquitoes breeding in irrigation canals.

A final consideration is that for CIFSRF, agricultural improvements should be environmentally sustainable. Considerations here include:

- Sustainable land and livestock management, including soil conservation, intercropping, nutrient management, interlinking livestock and cropping through use of manures and crop wastes;
- Integrated water management, including encouraging water infiltration in fields, draining fields without erosion, more economical irrigation, and preventing pollution of watercourses, water bodies and groundwater. It may also include protecting watersheds to improve water infiltration; and,
- Protection and enhancement of biodiversity through better pest and disease management that preserves ecologically important fauna and flora, crop diversification and use of native varieties and breeds.

Looking at all these potential considerations, it is not surprising that CIFSRF projects could potentially have contributed to the programme goal through many different activities and subsequent pathways to food and nutrition security impacts.

What is meant by research for development projects?

Expectations of CIFSRF are not just about the content of the projects: they apply as well to the way in which the projects might be carried out.

IDRC programme staff describe the projects as research for development (R4D) programmes; that is, research which is relevant to development, that links research to users through participatory action-research, and that incorporates results in development processes. How then does R4D differ from research alone, or from other development programmes?

The former distinction is straightforward: the projects are not pure research studies, where the prime output is a published paper recording the scientific advances achieved. Instead, they are trying to develop and test innovations with users to prove concepts, and find working models that can potentially be scaled up with widespread dissemination of the resulting technologies.

The latter distinction, between R4D and regular development projects, is a little more complicated. Many development programmes include some technical innovation: most agricultural development programmes, for example, promote some technical improvements — better seed, use of fertiliser, irrigation, etc. R4D

programmes differ in that initially the technology they test is not proven, at least not in the circumstances in question, and may not even be fully developed. R4D projects are thus about technical development, testing and refining technology in an applied context; to be followed by dissemination of what has been shown to work in a subsequent phase. While technical issues may be the initial concern, when learning to apply the innovation, social dimensions often become just as important.

This distinction has important consequences for design and implementation of development projects: one that has long been identified and its implications pondered (Korten 1980, Moris 1981, World Bank 1983, and more recently, Andrews et al. 2012). R4D projects have been characterised as 'human development' as opposed to 'physical development' projects (World Bank 1983), a distinction that recognises the importance of interventions in complex social systems to apply innovations for beneficial changes. The implications of that distinction were codified in the proposition that such projects should deploy a 'learning process', rather than 'blueprint planning' that would be appropriate for 'physical development' projects.[3]

The learning process involves devising action programmes at grassroots level through iterative processes of trying out ideas, closely monitoring the early results, recognising and accepting any errors, then being flexible to change activities as early results indicate — all directed towards finding a workable and effective model that addresses the development issue in question. Only after a working model has been devised, does the programme then look to make the model efficient and economical in use of staff and other resources. Pilot phases of projects often involve disproportionate application of staff time and other resources to the search for effective solutions. These can only be scaled up when more economical means are used.

R4D projects thus progress through phases, with significantly different forms of management in each of those phases. Early on, small teams of highly-qualified professionals operate at village level in small areas, usually a district or smaller unit, using informal processes, interacting closely with project participants and other stakeholders, in a stimulating and creative process.[4] Once a working model has been devised, then subsequent phases can be implemented more economically by more formalised procedures.[5]

2.1.3 What did the CIFSRF projects do?

The Phase 2 portfolio consists of highly varied projects, partly because they were selected from calls for proposals, some quite open. Promising proposals thus did not necessarily adopt similar approaches. That said, the 18 projects can be seen to cluster into groups (Table 2.1).

Most projects were concerned with one or more of four sets of activities, as follows:

- Increased production of nutritious crops and fish, largely for home consumption of the project participants;

[3] When the learning process was codified in the late 1970s and early 1980s, it attracted considerable interest among development practitioners: its high point seen when it was advocated by the World Bank, no less, in the 1983 World Development Report.

Hopes that aid agencies and government would recognise the learning process as an effective way to implement, at least in the initial phases, rural development projects, fell foul of bureaucratic requirements: few agencies could allow themselves to proceed informally. To some extent, this hindrance was bypassed when aid agencies increasingly began to fund non-governmental organisations to carry out innovative rural development projects.

The learning process, however, has been rediscovered in the new century, where it has been dubbed 'problem-driven, iterative adaptation' (Andrews et al. 2012).

[4] In the case of some CIFSRF activities the earliest exploratory work was done in laboratories where scientific ideas were developed into potential technical applications. These were subsequently adapted to circumstances and participants in the field.

[5] In management studies, the former mode of operation has been dubbed 'task culture', while the latter has been termed 'role culture'. (Handy 1993)

- Food processing and fortification to produce foods with added nutritional value in vitamins, minerals, protein, and probiotics;
- Nutrition education; and,
- Avoidance of losses of crops and livestock to disease and of crop spoilage.

Of these four activities, nutrition education was never the centrepiece or sole focus of the project: instead, it was a complement to other activities. Hence classifying by activity identifies three clusters of projects that variously: grow nutritious crops and fish ('grow'); process and fortify food ('fortify'); and, avoid losses and spoilage ('avoid').

The differences among the clusters are striking (Table 2.1). The grow group of nine tend to have a wider range of activities than the other groups and deliver a wider range of impacts. At the other end of the spectrum are the avoid cluster of four projects: focused on a single technical challenge that may well produce very large financial gains to the intended clients. In between lie the five fortify projects.

The clusters are not entirely exclusive: two of the grow group included food processing — Ethiopia pulses, West Africa vegetables; while India small millets from the fortify group still retained its interest in the production of small millets, that had been a major focus in the earlier phase of the project.

How relevant were the projects?

The CIFSRF projects have addressed, in varying degrees, all dimensions of food and nutrition security. All projects contributed to raising the **availability** of food, the first of the four pillars of food security proposed by FAO, be that through increased production or reduced losses of food.

Access to food, a second pillar of food security, was addressed in the grow cluster by working with project participants in need of additional food or a better diet to produce more for their own consumption — so that both availability and access were increased simultaneously. In almost all of these projects the focus of production was on produce rich in protein — fish, pulses, or in vitamins and mineral — fruit and vegetables.

In most cases, the grow projects raised cash earnings of participants, so that they could then afford a better diet, or could improve their health environment. For most participants and activities, such sales were secondary to home consumption, so that the amounts sold and cash earnings were limited. Some participants, however, did produce mainly for sale. Examples here include farmers producing tomatoes in polythene houses for sale in Nepal terrace farming, millet machinery makers and millet processors in India small millets, seed potato growers in Colombia potatoes, fruit growers in Nanotech for fruits, yoghurt makers in East Africa fermented food, and *paiche* fishers in Bolivia Amazon fish.

For the five fortify projects, in addition to their contribution to greater availability of nutritious food, processors and their employees saw gains in income that would allow them to improve their food security.

The avoid group reduced losses to producers, thereby raising incomes, and increasing access to food.

Concerning **utilisation**, five of the grow group included nutrition education, both to ensure that participants growing more nutritious food could make the best use of the extra produce, as well as to encourage behaviour change —better child care and feeding, hygiene, etc. — that would complement the food dimensions of nutrition. All the fortify projects also included nutrition education.

It was pleasing to see nutrition education included in ten projects. Given that most projects were led by people with education and experience in physical sciences other than medicine, this was by no means to be expected.

The final pillar of food security, **stability** of availability and access, was addressed by those grow projects that led to production of food in the off-season, or which diversified the range of crops and animals raised by participants, or both. The avoid group also increased reliability by reducing losses to plant and animal disease, and by lengthening the shelf life of fruit.

The nutrition issue most commonly addressed was that of micro-nutrient deficits: all the grow and fortify projects aimed to increase participants' intake of vitamins and minerals. Indeed, some projects were entirely focused on remedying a single deficiency: Tanzania fortified sunflower oil focused on Vitamin A deficiency, while India double-fortified salt concerned adding a second ingredient to salt, iron, to complement the iodine that had

long been included. The focus on micro-nutrients reflects international priorities: more people experience micro-nutrient deficits in the 2010s than suffer from under-consumption of calories and proteins (SUN 2010).

Five projects also aimed to increase the intake of protein, in the form of fish, pulses, and yoghurt – particularly Bolivia Amazon fish, Cambodia homestead food, Ethiopia pulses, Tanzania legumes, and East Africa fermented food[6]. Just one project aimed, among other things, to remedy calorie deficits: Vietnam therapeutic foods.

Another sole project addressed problems created by diets excessive in nutrients that lead to overweight and obesity and then to non-communicable disease. India small millets promoted consumption of millet foods — including using millet to replace rice and wheat in products such as *dosas (pancakes)*, since the low glycaemic indices of millet foods can help lower susceptibility to diabetes among consumers.

Table 2.1 The CIFSRF Phase 2 portfolio, by main activities

	Nutritious crop & fish 'Grow'	Food processing & fortification 'Fortify'	Nutrition education	Reduce losses & spoilage 'Avoid'
Colombia potatoes	■		■	
Cambodia homestead food	■		■	
Ethiopia pulses	■	■	■	
West Africa vegetables	■	■	■	
Bolivia Amazon fish	■		■	
Nepal terrace farming	■			
Kenya farm shop	■			
Ghana ICT extension	■			
Tanzania legumes	■			
India small millets	■	■	■	
Vietnam therapeutic foods		■	■	
Tanzania fortified sunflower oil		■	■	
East Africa fermented food		■	■	
India double-fortified salt		■	■	
Côte d'Ivoire coconut disease				■
Nanotech for fruits				■
Africa CBPP vaccine				■
Novel vaccines for livestock				■

Olive: primary focus; Gold: secondary focus

[6] India small millets also has a minor protein angle, as small millets tend to be a better source of protein than other staple grains like rice or wheat.

Table 2.2 Simplified theories of change for three clusters

	Grow: Produce nutritious crops and fish	Fortify: Process and fortify food	Avoid: Avoid losses and spoilage
Impact	Better nutrition: improved growth of infants, reduced incidence of micro-nutrient and protein deficiency	Reduced incidence of micro-nutrient deficiency in consumers, lower glycaemic index	Higher earnings to farmers and herders Possible reduced prices of livestock produce, fruit in markets
Results	Participants eat a more diverse diet, with increased intake of protein, minerals and vitamins Some cash earned from sales from part of increased production Some specialised production for market: seed growers, hatchling operators, *paiche* fishers, fish ponds	Consumers eat more nutritious foods Processors earn more	Reduced loss of: • Coconuts to CILY • Livestock to 6 diseases • Fruit to spoilage on tree, in packing, on shelf
Capacity change	Participants harvest more nutritious crops and fish	Processors adopt fortification	Farmers and herders adopt measures
Activities	Extend and test methods to raise yields per hectare or fish per pond Facilitate access to quality inputs — including seed and hatchlings, tools, and machinery Encourage more sustainable agriculture Education on nutrition: diet & food prep.; water and sanitation & hygiene; child care & feeding	Train small-scale processors to produce more nutritious foods: snacks from millets, pulses Train processors to fortify food: Vit A to sunflower oil; Fe and I to salt; green veg to porridge Consumer campaigns to promote fortified food	Find ways to combat disease among livestock and coconuts, train coconut farmers, [*work with veterinary departments to implement vaccination campaigns*] Train farmers and packers in use of hexanal to reduce spoilage of fruit
Projects in cluster	Colombia potatoes Cambodia homestead food Ethiopia pulses West Africa vegetables Bolivia Amazon fish Nepal terrace farming Kenya farm shop Ghana ICT extension Tanzania legumes	Tanzania fortified sunflower oil India small millets India double-fortified salt East Africa fermented food Vietnam therapeutic foods	Côte d'Ivoire coconut disease Nanotech for fruits Novel vaccines for livestock Africa CBPP vaccine

CIFSRF Phase 2 was not only about food and nutrition security, it was also concerned with environmental sustainability. The projects generally included measures to ensure the environmental sustainability of the activities they promoted. [See the sustainable agriculture synthesis for more details.] These measures belonged to two broad categories:

- **Avoiding harmful agricultural practices**; including sustainable land management, integrated water resources management, working with ecological processes, and reducing pollution and waste; and,
- **Enhancing the farming system as part of the ecosystem**; including conserving biodiversity, valued habitats and local resources; managing agricultural production processes for sustainability; and managing the physical infrastructure for sustainability.

The grow projects almost always included practices that were ecologically sensitive, that tried both to conserve resources and to work as far as possible with ecological processes — and to reduce the use of externally-manufactured chemicals.

Considerations of environmentally sustainable production did not apply to most of the processing activities in the fortify group. Neither did they apply to the avoid group of projects; except for Côte d'Ivoire coconut disease, where the methods to reduce the incidence of disease developed from ecological principles, rather than looking to control disease through heavy use of agro-chemicals. (Shaxson et al. 2018, country reports)

Who did the projects work with?

In terms of **project participants**, the grow and avoid projects worked primarily with small-scale producers of crops, livestock and fish. In addition, some of the grow projects included input providers, such as seed growers (Colombia potatoes, West Africa vegetables) and fish hatchling suppliers (Cambodia homestead food); artisans and retailers (Bolivia Amazon fish). The five fortify projects worked with small-scale food processors.

In almost all cases, the project participants came from rural households and on low incomes.[7] In at least half the projects, women made up the majority of participants.

Projects had been targeted by considerations of where people on low incomes were living, and where food and nutrition security was problematic. Choice of location, however was not purely based on need. Project working sites had to be reasonably accessible, and of course had to have the physical conditions that would allow innovations to succeed. In addition, projects tended to work in locations where local partners had experience and had established good working relations with rural communities and local authorities — in some cases during CIFSRF Phase 1, in others earlier than that. Given the innovative, pilot nature of the projects it would have made little sense to work in more remote areas, lacking some aspect of the physical conditions necessary to test innovations, or where the partner had little experience. Failure under such circumstances would not help to learn about the innovation and its potential.

Within the chosen locations, project teams tried to select producers who were on low incomes, and to select women participants; but this was not exclusively so. Others in the community who were probably modestly comfortable also participated. In no case did project leaders look to work only and exclusively with the most disadvantaged, such as landless households, those living with disability, or marginalised social groups. The projects were concerned to test innovations and assess how they might be scaled up: that meant working with those who had the land, labour, experience and ability to adopt. Moreover, the projects had to work with the social grain: it is usually less easy to get local leaders and opinion-formers to consent to productive projects — things differ if the project is clearly seen as welfare — if the project does not work with a range of farmers in the community.

In Cambodia homestead gardens, when baseline surveys were carried out in the first phase comparing project participants to control households, the latter had lower incomes than participating households. Evidently the project had not targeted the poorest.

Overall, some project participants were far from being the poorest and most disadvantaged in their communities. That said, there is no indication of projects having been captured by local elites.

Targeting will be further discussed in the conclusions.

3. Effects and impacts of CIFSRF Phase 2 projects

In posing the central question of the contribution made by the CIFSRF projects, this section begins by looking at how the projects were implemented, including the research partnerships created, before examining their results, impacts, and policy influence.

[7] India double-fortified salt and India small millets also worked in urban areas, while West Africa Vegetables included work with prison inmates

3.1 Implementation

In visits to the field it was quickly apparent how dedicated the field teams were to the projects funded under CIFSRF. Interviews with Canadian partners invariably gave the same impression. Conventional evaluation does not often explicitly consider, nor is there a ready way to measure, the quality of field teams, their effort, determination and flexibility. It was however clear from the six field visits that CIFSRF partners have been well above average compared to the review team's knowledge, in their experience and skills, and in their enthusiasm and determination to achieve results.

The sheer volume of activity impressed as well: the field teams had spared no effort in adding in extra activities when and where they were appropriate. They had also been ambitious in the number of groups of participants that they worked with.

Developing country partners, moreover, usually had much experience of engaging with rural populations: that experience meant that planned activities were usually successful either in their original design, or after some adaptation.

Those qualities had two key results. One was that when obstacles were encountered, when the planned activities needed modification, the fields teams had been prepared to adjust, to rethink, to work again to get results. The projects were thus examples of using the 'learning process' (section 2.1) to good effect in rural development.

The other consequence was that project participants recognised these qualities as well: many responded well to the combination of dedication and technical expertise and were proud to participate.

3.1.1 How did the research partnerships function?

At least three things had been achieved in the CIFSRF Phase 2 portfolio through the partnerships between Canadian research centres and their developing country counterparts.

The most common outcome was the creation of **additional capacity** in the partner countries. In almost all cases, the local partners were supported and enabled to carry out additional activities. In some cases, the technical capacity involved advanced technology, with Nanotech for fruits an outstanding example in enhancing scientific and technical skills at Tamil Nadu Agricultural University. Other examples include the work on potato genetics in Colombia potatoes, and the *GlnLux* technology to assess nitrogen fixing by rhizobia in Nepal terrace farming.

Capacity was created at all levels for local partners; from the project leaders to the field workers. Given that field workers were often young and were little-travelled, the opportunities afforded by the partnerships with international researchers were striking.

The second contribution was **mutual learning** in field activities. Not all Canadian partners had much experience of field conditions in the developing world: the CIFSRF projects provided those Canadian partners the opportunity to appreciate those conditions, and to learn how their knowledge could be put to use. Capacity was thus created in Canada, as well in the developing countries.

A third contribution was **joint scientific research** into the development issues in question, mostly addressing the physical science.[8] Several projects generated an impressive number of papers reporting on this research — with Nepal terraces a good example, where by July 2017 no less than 45 publications had been drafted, 35 of them formal research papers for journals and books. Often considerably more papers had been written than might be expected from R4D projects where the need for action in the field can leave little time for documenting what has been learned.

At least two factors help explain success seen in the partnerships. One is that many of the leaders and senior

[8] For example, of the 35 scientific papers published, or in preparation, by the Nepal terrace farming team as at July 2017, six focussed on social science.

staff engaged in the projects, both Canadians and developing country partners were outstanding in both their technical competence and in their commitment to the programmes. Again, this factor is not easily measured, but in many interviews with both sets of staff, their talent and enthusiasm shone through.

The other factor in play here was IDRC support. Project teams had been trusted to implement as they saw fit, and granted latitude to make changes, or to add activities. Moreover, IDRC programme staff had been considerably active in visiting, advising and supporting the projects in their portfolios. IDRC had also brought some of the teams from different projects together for workshops on topics such as scaling up and gender. It would have been possible to manage the portfolio largely by checking disbursement of funds and reading reports — some other agencies that fund development research have little time to do much more than this; but the IDRC staff had done much more, engaging with the technical content and the development dilemmas encountered, and looking for ways to help the field staff make progress. This support was much appreciated by both the developing country partners and Canadian researchers interviewed.

The field work and review of documents focused first and foremost on the projects, their activities and outcomes rather than the partnerships. From this relatively light review, no significant problems in partnerships that affected the outcomes of projects were apparent.

The question of the human dimensions of implementation will be taken up again in the conclusions.

3.2 Results and impact

3.2.1 What results were observed?

This section draws on what had been recorded and observed by May 2018 for the different projects, including in most cases but not all, final technical reports. Few of the projects had carried out systematic evaluations of their results by this time: most of the quantitative data came from internal project monitoring of the results achieved by project participants. In relatively few cases — five noted — were comparable data from control groups available.

Hence in what follows, the nature of the evidence on results and impacts relies heavily on the logic of the theories of change. That is, if the activities planned were implemented, if project participants changed their behaviour in expected ways, then any expected results and impacts observed could then reasonably be attributed to the project — unless some evidence existed that other factors might have led to the results seen.

The synthesis of results is organised by three clusters of projects identified. Details of the results observed for each project in terms of increased agricultural productivity, income and nutrition can be seen in Appendix B.

Grow nutritious crops and fish

The grow group had largely succeeded in raising the yields of nutritious crops, fish and other produce. For example, intercrops of legumes among cereals had led to 26–30% yield rises in Nepal terrace farming, green leafy vegetables yields increased by 57% for West Africa vegetables, fish pond output had risen by 137% in Bolivia Amazon fish, maize yields were up by 230% for Ghana ICT extension, and milk yields had increased by 13% for customers of Kenya farm shop. The area under sustainable agricultural use had been expanded. For Cambodia homestead food, 53% more households had started home gardens. The area under improved yellow potato varieties in Colombia had grown from zero to over 730 hectares, 16% of the area planted to yellow potatoes. West Africa vegetables saw land planted to green leafy vegetables increase by 1.5 times in Benin, and by 7.7 times in Nigeria.

Almost all these grow projects had undertaken activities to make agriculture and fisheries more sustainable. All had evidence of uptake by farmer participants. Some results were readily observed in the field visits or logged in the technical reports: increased crop cover on Nepal terraces; increased ranges of plants grown in Colombia, Benin and Nigeria; and revegetation of upper catchments in Colombia. Colombia potatoes reported that 87% of farmers reduced agrochemical use and 62% adopted recommended soil protection. Participants in the Colombian home gardens had enthusiastically taken up agro-ecological methods and planted landraces, not only for environmental sustainability but also to recover their heritage.

In the six field visits, evidence that these increases in production were contributing to better diets was limited; often limited to the usually positive responses from participants interviewed during the field visits. In Colombia potatoes, however, surveys of farmers participating in field schools, tilling collective and household gardens, showed marked increases in diet diversity scores. Such scores had also been measured and found to increase among participants in the first phase of Cambodia homestead food.

Although most of the production encouraged in the grow group was for home consumption, many participants were able to sell some of their increased output: small quantities of vegetables from home gardens, of fish from ponds, or of increased fish catch from rivers. Generally, the gains per participant were modest, of US$100 a year or less. For example, women farmers growing ginger as an intercrop typically realised sales of US$30 in Nepal hill terraces. Indigenous fishers in Bolivia Amazon fish saw their returns from catching *paiche* rise by US$20–80.

These extra earnings may not be large, but in some cases came in the agricultural off-season, when any cash income is especially useful. Often the cash was earned directly by women, disproportionately increasing their control over cash, with the likelihood that it will be spent on food and other basic needs of the household.

In some cases, however, when farmers produced high-value items, including seeds and hatchlings, the income gains were larger. Nepali hill farmers using polythene houses of 50 square metres with drip irrigation to grow tomatoes could make gains of US$200 over three years, net of the costs of the equipment. West Africa vegetables reported half-hectare vegetable plots in Benin and Nigeria producing net benefits of US$3,500–4,000.[9] Most fish farmers in Bolivia reported incomes rising by 50–100%, with household incomes rising by over US$11,000 between 2015 and 2017 — although it is not clear just how much of this comes from increased production of fish.

Six of the ten grow projects provided nutrition education. Evidence of changes to behaviour was largely limited to responses from project participants interviewed during field visits, who generally confirmed that they were following advice. In Cambodia homestead gardens, participants reported more exclusive breastfeeding, use of water filters and more washing of hands.

Evidence on nutrition impacts by May 2018 was limited. In Cambodia for instance, project participants interviewed felt diarrhoea among children was declining. Since the same was seen in control villages, it was however not that clear to what this may be attributed. Ethiopia pulses, on the other hand, demonstrated a positive impact on dietary diversity among mothers participating in its nutrition education activities.

Process and fortify food

The prime benefit of the fortify projects was to consumers of the fortified foods. Evidence of this, however, largely consisted of earlier trials that registered benefits to those consuming such foods — for example, a growing medical literature exists on the benefits of probiotics being added to yogurt in East Africa fermented food, namely improved health of digestive tracts and less diarrhoea. The benefits of fortifying salt with both iodine and iron, as was done in India double-fortified salt, is also documented, the added iron reducing anaemia.

Proof that these benefits were effective among the consumers was limited to two studies. One, a field survey carried out in Tanzania to look at the effect of Vitamin A supplementation of sunflower oil, confirmed that the expected impacts of reduced deficiency of Vitamin A were being realised, and that the consumption of the fortified oil was the most likely cause. Two, two trials of probiotic yogurt with schoolchildren in Tanzania and Uganda showed some health benefits through time, although no controls were included.

[9] It is not known, since this project was not visited in the field, whether these sums are annual, or accumulated gain during the life of the project. They are, however, such large sums, that even if the cumulative gain over three or more years, they would still be large. It is just possible to realise such high returns from a year's work, when vegetables are raised with irrigation in good conditions, and when high-value perishables are being produced. Economic gains of more than US$10k per hectare have been observed for tomatoes on virgin irrigated land in Kenya, for example.

Nutrition education was included for all the fortify projects, although this was largely directed to explaining to consumers the benefits of the fortified foods, rather than a full set of nutrition messages. Comprehensive messages, however, were provided to mothers in Vietnam therapeutic foods.

The processors themselves were expected to earn more. In East Africa fermented food, the profit per litre from selling probiotic yoghurt was at least three times that of selling milk. Increased earnings from selling probiotic yoghurt instead of fresh milk averaged US$95 per week per production unit in Uganda and US$193 in Tanzania. India small millets reported income gains for makers of millet dehullers, millet food processors and vendors.

Gains from additional employment created by processing were rarely reported, with India small millets the exception. A manufacturer of millet processing machinery in Coimbatore, Tamil Nadu, India reported that increased demand for machines meant salaries of workers had risen from around ₹350 a day [US$5.38] in 2014 to as much as ₹700 a day [US$10.77], while profits per machine remained the same. Similarly, for an engineering firm in Salem, Tamil Nadu, labour costs had increased more than 50% in the last 5 years, owing to the firm hiring 14 more workers, to add the 6 already employed, as well as to wage rate increases.

Avoid losses and spoilage

The results of the avoid group were very largely those of increased earnings to producers who experienced fewer losses than before.

For example, Indian fruit growers conserving their produce with hexanal realised a gain of US$295 per tonne of fruit harvested. Mango famers estimated they made US$670 more from every acre under fruit by using nanotechnology.

The gains from livestock vaccines could be very large indeed. In rural Africa, the loss of a cow can be worth US$500 for local breeds, and three times that for specialised dairy breeds; a sheep or goat lost may be worth US$100. Given that disease control and avoiding spoilage of fruit could apply across many countries and hence to millions of famers, the aggregate gains to these projects could be very high indeed.

Within the avoid group, Nanotech for fruit reported the environmental benefit of reduced need for chemicals, as disease incidence fell by 20% when the hexanal sprays were used on fruit.

Unexpected results

Some projects had unexpected results, although it was generally only possible to appreciate these for the six projects visited in the field. For example, Colombia potatoes had been able to work more, and more effectively, with indigenous communities in Nariño than had been expected given the difficulties that can apply when working with communities that have been disadvantaged and that had been living with conflict until recently. In Nepal terrace farming, the field team worked with women farmers to improve their farming; but it was also clear from interviews with groups of women farmers that this work empowered women, giving them greater capabilities, independence and self-esteem.

In sum, from the data available by May 2018, it would seem that most activities of most projects were succeeding in what they planned to do: most innovations were effective, as far as this could be traced along the theories of change. In some cases that was only as far as behaviour change, in others there were results observed as well, and in just a few cases, impacts had been registered. The absence of evidence should not, however, be seen as evidence of absence: lack of data on impacts does not mean they do not and will not exist, but rather that they have not been formally observed and measured. This does not surprise: project teams had more than enough to do, without conducting detailed surveys of results and impacts.

3.2.2 What influence did the projects have on policy?

All the projects engaged with policy-makers and opinion-formers in the countries. Such engagement varied in the issues addressed and the depth and breadth of encounters with public officials.

The most common interaction, seen in many projects, was sharing information on activities with government agencies to **coordinate field activity**. This usually

concerned one or two agencies at the relevant level for field operations, commonly a district or province. Considerable effort went into establishing effective working relations with public agencies.

In some cases, collaboration went further, as the project helped develop capacity in the public agencies. For example, in Colombia potatoes, the project team helped train health staff at municipal level in the use of micro-nutrient powders. Bolivia Amazon fish also worked closely with government staff, above all on the ecology of common fisheries. India double-fortified salt worked with staff of the state public distribution system on how to include the salt as part of the foods distributed.

In some cases, policy influence amounted to **raising awareness of new products**, in effect marketing the technologies being developed and tested. For example, Colombia potatoes actively engaged with public bodies directly, and with the wider public through radio and press, to advertise the new varieties of yellow potato developed by the project.

More challenging interactions concerned projects where policy change was needed for the success of project activities. In such cases, repeated interactions were necessary with officials and agencies at national level. For example, some projects required **approval of technical innovations by regulators**. Examples include the approval of hexanal to spray on fruit or to line packing materials (Nanotech for fruit); and getting vaccines through safety scrutiny (CBPP vaccine, Novel livestock vaccines).

In other cases, policy changes could have been significantly helpful for the project. For example, in Tanzania small-scale vegetable oil processors would have benefited had food-grade plastic tanks been allowed, rather than the costly metal ones that has been adopted as a standard. West Africa vegetables worked with the Nigerian standards organisation to establish standards for pastries containing added green vegetables.

Occasionally, **laws to confer rights and responsibilities** were central to the project; as applied in the case of regulations to empower local collectives to manage river fisheries in Bolivia Amazon fish.

Several projects were successful in getting **ministries to adjust their priorities, or to undertake additional programmes**. Tanzania legumes convinced the Agricultural Seed Agency to develop stocks of foundation seed for beans and soybeans, to step up measures against fake seed, and to harmonise seed testing and release across the East African and Southern African economic communities. In Vietnam, the work of therapeutic foods led the government to review policies to reduce malnutrition among minorities. Ethiopia pulses raised the profile of chickpeas with the government, while India small millets pushed millets up the public agenda to be considered a priority orphan crop.

In other cases, **public procurement** was seen as a significant channel to disseminate and scale up the innovation, as applied for India double-fortified salt and Vietnam therapeutic foods. Public procurement was also a potential avenue to market produce from India small millets, Colombia potatoes, and some of the West Africa vegetables.

Influencing policy tends to be a medium to long term endeavour, so that in most cases, other than field coordination, the full results remain to be seen. Nevertheless, so far most of the CIFSRF projects seemed to have been able to influence the policies and activities of public agencies that mattered to them.

Few projects were stymied by failing to influence public agencies or policies. The exceptions apply to product-specific regulations, where a focus on developing and testing the technology had seemingly left too little time and space for adequate attention to ensuring that the resulting embodied technologies passed public scrutiny and approvals.

That, however, may simply be a matter of sequencing. It is difficult to begin the procedures for official clearance, until the product is clearly defined and field evidence of effectiveness and innocuity can be demonstrated. In these cases — CBPP vaccines, Novel livestock vaccines and Nanotech for fruit, — however, it seemed that the products would be approved, given time for the necessary procedures to be carried out.

Al the cases where policy influence was achieved, both for the benefit of the project and more widely within the country, the common element was repeated interactions between policy staff and their counterparts in

government. In some cases, this was augmented by training government staff. In policy influence, it seems, patience and effort paid off.

4. Sustainability and prospects for scaling up

Sustainability and scaling up are closely related, since the former is a pre-condition for the latter; while a project that was sustained but not scaled up would represent a limited success.

4.1 What conditions were needed to sustain activities?

Most development interventions require one or more of four sets of conditions if they are to be sustained. One is that private actors — households, farms, firms — can gain from innovation. The producers, input suppliers, buyers, processors, etc. will be motivated to continue because the new activities generate attractive returns to business.

A second consists of the provision of public services and programmes, generally delivering public goods that would not otherwise be provided by the private sector. Activities will be sustained so long as ministers decide that they are worth the public spending involved.

A third set of conditions comprises collective action either to produce a good or service, regulate and govern the use of a resource to the benefit of most or all users, or to secure some advantage to the collective — such as a public subsidy or tax exemption, or collective bargaining with employers. Successful collective action arises usually when the good, service, governance, or advantage cannot be created by an individual producer or firm. The common benefits to members of the collective ensure that they continue with their efforts.

A fourth set consists of public policies that either mandate or highly encourage some activity or practice, such as a regulation that compels salt processors to add iodine to the salt. That will be sustained so long as leaders believe the regulation to be in the public interest.

This simple framework can help appreciate the prospects for sustaining CIFSRF activities. Details of these considerations for each project appear at Appendix E.

Private gains. The innovations promoted by the CIFSRF projects are likely to be sustained when clear financial and economic gains accrued to project participants. This applied to the farmers and fishers in Bolivia Amazon fish, Cambodia home gardens, Colombia potatoes, Ethiopia pulses, Ghana ICT extension, Kenya farm shop, Nanotech for fruit, Nepal terrace farming, Tanzania legumes, and West Africa vegetables. It should also apply to machine makers, processors and retailers in East Africa fermented food, India small millets and Vietnam therapeutic foods. It may well apply to coconut growers in Côte d'Ivoire coconut disease and to livestock keepers who should, in the near future, benefit from disease controls and two sets of livestock vaccines.

Private gains are likely to be sustained provided that: participants see benefits as greater than costs; that produce can be sold at a rewarding price; and, that inputs and technical advice can be obtained. These deserve further elaboration.

In many cases, the benefits of the activities promoted under CIFSRF clearly outweighed the costs. This was not always evidently so: simple economic calculations, such as gross margin analyses, had not been carried out systematically for all economic activity.

In a few cases, there were reasons to wonder just how beneficial the innovations were. For example, the costs of new practices can be high, as one of the groups growing seed potato in Colombia discovered. This is not unusual in pilot projects where the aim is to find effective solutions, and only then to look to find economic ones. Developing technologies, and adapting them to new conditions, can require unusually high initial costs. The attendant danger is that project teams may be insensitive to high costs, especially those of labour — since they are less readily apparent than cash spent in equipment and inputs, so that it may not be possible subsequently to economise and still have an effective innovation.

While markets exist for much of the additional produce generated by the projects — unsurprising since few projects engaged with entirely novel products, in some cases it remains to be seen how strong demand will be. In Tanzania, soybean growers found it hard to sell their produce — although this may prove to be a temporary obstacle. In Colombia, the market for new varieties of

yellow potato had yet to be tested: will consumers prefer the improved to the existing varieties, and will they be prepared to pay a premium for the improved ones? For seed potato growers in Colombia, it is not yet clear just how large the market for certified potato seed is. In Ethiopia, farmers growing quality legume seed found the state enterprise that was supposed to buy their output was slow to pay, so slow that in some cases they had to sell the seed as food, at a discounted price.

Some activities rely on access to specialised inputs and advice that may not be so reliably supplied when the project is not there to support the participants. The need for special assistance is never higher than when hazards strike; for example, attacks of previously unknown pests and diseases, or a drop in market prices. Both can lead to activities being abandoned, yet the former may be treatable, given appropriate advice, while the latter may be temporary. So long as the projects were active, additional resources and specialist advice could usually be found to confront such problems: subsequently, these may be lacking. In Ethiopia, for example, farmers were concerned that coming changes to climate would undermine their ability to grow legumes. To some extent these risks are linked to the next aspect of sustainability.

Public services. Few of the projects were primarily engaged in generating pure public goods and services, but some examples could be found in the portfolio. The most common was nutrition education, found in most of the grow and fortify projects. Ideally, these should be sustained by government as part of primary rural health services.

Some of the private goods produced had merit[10] characteristics. For example, much merit applies to fortifying salt and vegetable oil, an advantage that may not be fully appreciated by consumers who find it difficult to relate the added characteristics of salt and oil to their future health and wellbeing. In such cases it may be in the public interest either for government to subsidise the provision of the merit elements, or to make provision compulsory. Similar considerations apply to vaccinations and crop disease control, where externalities from users to non-users — a cattle herder with vaccinated stock is less likely to transmit disease to other herders — justify public investment.

Public services, nevertheless, will matter to projects that depend on services that, while private in nature, are nevertheless under-provided by private firms in conditions of little-developed rural economies. For example, for crop and fish farmers, agricultural extension services will be valuable. In some cases, project participants may have access to private advice from input dealers who know enough to help, or from a co-operative; but most will depend on whatever public extension is on offer.[11] In the long run, private services may replace public ones, as farmers come to appreciate advice to the point where they are prepared to pay for it.

Collective action. In some cases, collective action may be needed to sustain activities. The management of the *paiche* fishery in northern Bolivia, the Colombia communal gardens ('*shagras para la vida*'), are cases in point. Other projects include less complicated, and less critical collective action, such as the use of social networks to help market innovative produce (India small millets, East Africa fermented food). Collective action faces significant challenges in avoiding free-riding, in coordinating efforts and leadership: intangible costs that are not to be underestimated.[12] They can work without external support, but much depends on circumstances, events and leaders.

[10] Economists refer to 'merit goods' to indicate those goods and services from which citizens benefit more than they may imagine, benefits that are prized by society as a whole, since the benefits to the individual also benefit others in society — that is, externalities arise. Public libraries would be an example, as would be vaccination, and primary education.

[11] Increasingly, information technology can supplement face to-face advice: texting services, help lines, and internet platforms are increasingly available, especially in emerging economies.

[12] Development programmes have commonly discounted these costs, assuming some homogeneous village society capable of deep and wide-ranging collective action, often in realms never before attempted by village leadership. Failure has thus been commonplace. (Curtis 1991; Johnston & Clarke 1982, Chapter 5; Wade 1987)

Policy. Just a few projects depend on specific policies for their sustainability. In two cases, the necessary changes were achieved under Phase 1, as with the governance of common fisheries in Bolivia and seed regulations for legumes in Tanzania. Those that will depend on policy in the future include Nanotech for fruit in countries other than India where the innovations have been approved, and the two vaccines projects, where the technology needs to be approved for use. A few projects would benefit if there were public procurement of produce to ensure and expand the market for produce generated by the projects. This applies to the yellow potatoes in Colombia potato, small millets and double-fortified salt in India. Finally, projects fortifying food would benefit if fortification were mandatory, as applies to vegetable oil in Tanzania and salt in India.

What seem to be the prospects for sustaining the main activities —at least 42 can be identified, see Appendix C for the list of these — of the 18 projects? Most project leaders were optimistic that innovations that have worked will be sustained. The large majority of activities lead to material gains for project participants. In most cases it is reasonable to expect them to be sustained. The qualifications apply in two situations. One is where the activities depend on specialised inputs and advice that cannot necessarily be readily sourced from private concerns, at this stage of rural development. As mentioned, that is likely to apply to the more complex technologies that depend on adaptation to local conditions — intercropping, pest management, for example; rather than to simple techniques often embodied in tools that can be used with little adaptation.

The other is where the benefits are either intangible, delayed, or where cause and effect are less than obvious. For example, following advice to wash hands with soap, or to filter water, does not clearly and immediately lead to better health. Farming systems that make full use of ecological processes tend to yield benefits in the medium rather than short run, benefits that may be diffuse — for example soil quality and health — and hard to attribute to the ecological practice.

In some cases, it was hoped and expected that local governments and district authorities would take on initiatives that provide public goods and services, inspired by the project. Where close working relations had been established between the project and government agencies, for example in southern Colombia, and southern Ethiopia, such hopes were well founded. Indeed, by May 2018 the provincial government of Nariño in southern Colombia was committed to rolling out the food security schools across 18 municipalities, a considerable step up from the five localities where the schools were piloted by Colombia potatoes. In other cases, the local partner in the project was a well-established NGO that will probably continue at least some of the activities, at some scale, in the future as part of its regular programmes — quite possibly by seeking funds to that end from another donor. Helen Keller International in Cambodia and LIBIRD in Nepal are good examples.

Just a few projects, however, needed to resolve significant problems to be sustained. Regulation and approval of products and techniques remain as thresholds to be passed for Nanotech for fruit, CBPP vaccine and Novel vaccines. The small-scale processors in Tanzania fortified sunflower oil had encountered diverse difficulties in accessing sunflower seed, in maintaining equipment, and managing cash flows. One seed potato-growing group in Colombia had yet to find an economic model for their production. Some of the legume farmers in Tanzania had not found the market they expected. Seed growers in southern Ethiopia found the state company an unreliable customer. In Ghana, a business model for the radio extension had to resolve the question of just who pays for the radio programmes.

Some of these may be temporary obstacles that will be overcome: it would be surprising, for example, if a successful livestock vaccine were not to be approved, albeit with some delay — it is not as though vaccines are conceptually novel (see discussion of novelty in the final section). Use of hexanal is novel — as a nanotechnology it may be subject to different regulations than other forms of plant protection — but if it is innocuous, why would this not be approved? Similarly, finding ways to cut the costs of growing seed potatoes in Colombia should be within the compass of the talented field team to devise with the seed growers.

A final caution: not everything will be sustained at the level achieved in the early phases of projects. The transition from pilot project conditions to regular operations inevitably leads to some loss of effectiveness (Korten 1980). If some effectiveness is then lost, the saving grace is that innovations may then be applied at scale — so that far greater reach compensates for a lesser degree of change.

4.2 Prospects for scaling up

Scaling here is taken to mean imply two things. One is that the innovations created would be on offer to users across much of the territory in which they would be suitable. Concomitant with this, impacts wold be realised on a scale many times — at least an order of magnitude more than — that of the original participants. The other is that scaling of innovation be by an agency intended to be longstanding[13] — be that a formal public organisation, civil society body, or private sector enterprise — rather than by a temporary project

In spite of IDRC's efforts, asking for plans for further scaling up, and offering workshops to support project leaders on further scaling up, by early 2018 most projects were in the early stages of trying to scale up their innovations. Most were operating at district or regional scale, rather than national. Impacts were being seen among limited populations. Few projects had significantly expanded the territory and population served during Phase 2. Most were using project structures and finance to operate, rather than operating within a more longstanding, likely-to-be-sustained framework.

Exceptions could be seen: the double-fortified salt in India was being rolled out across at least two highly-populous states, primarily through the public distribution system — a very large, nation-wide system with decades of experience of distributing staple foods at subsidised prices to people on low incomes. Ghana ICT extension was operating nationally as well.

At the other end of the spectrum, however, were projects that were still working to prove concepts, and hence had yet to begin to establish working models that might scaled up. The two vaccines projects were the main examples.

Much of what has been done in CIFSRF Phase 2, including those programmes that had a Phase 1 project or antecedent, was to arrive at a proven concept and a working model. This provides a useful start for scaling, but much remains to be done before initiatives can be both sustained and operate at anything like their potential scale.

In many cases project teams, and especially the local partners in country, were hoping that when CIFSRF funding ended, either some other donor would continue the funding, or that government might continue the programme, or that they could carry out some of the activities using their core resources as best they could. Not many projects appeared to have reasonably specific plans on how these things would be done.

This was not that surprising. The logic of R4D projects, see section 2.1, is to focus first and foremost on proving the effectiveness of innovations as development interventions that benefit participants. That takes considerable time and energy, a theme to which this review will return in the conclusions. Not only is it hard to focus on subsequent scaling up, but also it may not be entirely evident what that scaling up may involve, even in technical terms, let alone in social and institutional requirements. Moreover, teams that work well in proving concepts in the field, may not be well disposed to consider scaling up where some effectiveness will almost always be lost to more formalised procedures, to more bureaucratic — technical, Weberian use of the term[14] — operations.

[13] One might say 'permanent', but few organisations exist for longer than the medium term, especially private enterprises.

[14] Max Weber documented the functioning of large, formal organisations that had proliferated in industrialising countries in the nineteenth century, organisations which he called 'bureaucracies'. He saw these as highly effective, professional organisations that could accomplish tasks that no other form of organisation could. He has been proved right: the majority of public and private activity in high income countries today, and especially activities which are complicated and operate at medium to large scale — most public services, much manufacturing, banking, logistics, etc.

The diversity of CIFSRF Phase 2 projects was noted in section 2.1: a considerable difference can be seen between the technically ambitious projects that were, even in Phase 2, concerned with developing concepts — such as CBPP vaccine, Novel vaccines, Nanotech for fruits — and those that were by Phase 2 for the most part rolling out fairly well-known technology, such as Cambodia homestead gardens or West Africa vegetables. Paradoxically, the route to scale up the more technically ambitious projects may be clearer than that for the technically less ambitious efforts. But to appreciate that, it is helps to consider what may drive scaling up.

These drivers turn out to be largely three of the same considerations for sustainability: private gain, public services and collective action.

Scaling up where **private gain** is paramount usually requires little public action. Farmers and others in the supply chains should replicate innovations, provided that they have the information about the gains on offer, they can access any products that embody the innovation, and they can gain whatever capabilities they need to operate the innovation effectively. None of these should be too demanding for innovations that generate significant private rewards: private enterprise will have the incentives to spread knowledge, stimulate demand, and support users. The users, for their part, have ample incentives to learn about the innovation and how to apply it.

Public action may complement this, by guaranteeing that goods whose quality cannot be immediately and visually assured are indeed of the quality claimed — for example, the public certification of seeds; or that innovations are safe in application. Public information may complement private advertising, providing some reassurance that claims by private firms are what they say — eventually developing countries will have effective advertising standards as well.

Many of the CIFSRF Phase 2 projects generate private gains, by raising the productivity of farmers. Where the innovation is very largely embodied in a product, then private enterprise should be an effective means to scale up innovations. The exemplars here are hexanal sprays and stickers, and vaccines. Users do not need to know much, if anything, of the science behind the innovations, but only need to follow fairly straightforward instructions. Potential commercial suppliers of these innovations should be very interested in acquiring the technology to produce them for sale; as has happened with the Enhanced Freshness Formulation sprays from Nanotech for fruits.

Some labour-saving tools have similar characteristics. The use of many farm tools can rapidly be grasped by most farmers, with minimal instruction. The hand-held corn sheller in Nepal has been an instant success with farmers.

Most agronomic — as opposed to mechanical — innovations, however, are not quite so straightforward. A quality seed, for example, may be a simple product, but it will only produce higher yields if the farmer understands the characteristics of the variety and how it can best be grown. Hence the incentives of private gain must be complemented by information and training, which is most likely to be provided publicly in low-income countries, since private sources of these are often little-developed in rural areas.

Scaling up where **public services** are required is largely a matter of policy influence; of getting political leaders to agree that the innovation is worth public investment to build on and expand the early pilot. Several CIFSRF projects will require this, most clearly for the vaccines. Although vaccines are private goods that confer largely private gains, social externalities apply since non-vaccinated herds are likely to benefit from healthier vaccinated herds. Moreover, vaccines usually need to be administered following veterinary protocols to make them safe and effective, a discipline that may — at least initially — be best enforced by public programmes.

The innovations in Nepal terrace farming comprise some which are embodied in tools that may best be distributed through private enterprise; but other more agronomic

— is carried out by organisations that largely follow the principles of bureaucracy in their structure and systems that Weber codified.

measures involve messages that are public goods — non-excludable and non-rivalrous.[15] The latter will not be supplied privately, hence they require public provision. One way to do this would be to invest in the agricultural extension service of Nepal, to give the service the resources to add the Nepal terrace farming messages to the existing portfolio of messages and campaigns. This, however, requires funds from either the government budget or donors. Given such finance, however, the challenges of scaling these innovations is relatively straightforward: they are largely those of running an effective and productive agricultural extension service. Indeed, the extension service should welcome the additional messages, and some of the tools to help spread them — such as the picture book and the You Tube videos, since potentially this would equip them better to serve farmers.

The same would apply to other projects that have public-good messages: Bolivia Amazon fish, Cambodia homestead food, Ethiopia pulses, and Tanzania legumes.

Those cases where **collective action** is central are perhaps the most demanding of all to scale up. While it is possible to create model organisations for collective action, each and every separate entity usually needs adjustment to local circumstances. Providing support and resources to facilitate the formation of effective collectives thus requires tailoring to circumstances and can be demanding. For CIFSRF Phase 2, however, collectives are perhaps critical in just a few cases, such as the Bolivian *paiche* fisheries and the Colombian communal gardens mentioned. Indeed, while Bolivia Amazon fish has been obliged to work towards collective management of river fisheries[16], when it came to the fish ponds, the possibility of collective ponds was soon shelved in favour of individual ponds.

5. Conclusions, discussion and lessons

5.1 Main findings summarised

To recapitulate, the main findings from this study may be summarised as follows.

Nature and relevance

[Section 2:]

The 18 projects of CIFSRF Phase 2 make a up a diverse set of projects, but they can be clustered into three groups according to their strategies and activities. Nine projects were concerned with growing nutritious crops and fish, primarily for home consumption by the participants. Five projects worked with small-scale food processors to produce foods with added protein, vitamin, minerals and probiotics. Four projects were concerned with avoiding losses of crops and livestock to disease and spoilage.

Each project addressed one or more of the four dimensions of food security — food availability, access, utilisation, and stability. For the grow and fortify clusters, the main contribution to food and nutrition security was through reducing the incidence of dietary deficits of protein and micro-nutrients. Projects in the avoid cluster improved food security by increasing food availability and raising producer incomes thereby potentially increasing access to nutritious food.

Project teams targeted participants by location, choosing rural areas where most households were on low incomes; subject to the area having the conditions to test innovations, being accessible, and being somewhere where the local partner had experience. Within communities, projects worked with a range of participants, without further trying to select those on the lowest incomes or otherwise disadvantaged.

[15] From the theory of goods in economics. Non-excludable goods and services are those where non-payers cannot be excluded from enjoying the benefits. Non-rival goods and services are those where the benefits received by any party do not prevent others from enjoying similar benefit. Pure public goods are both non-excludable and non-rival: for example, street lighting, cleaner air after controlling pollution, defence, radio broadcasts, etc.

[16] A hard road, but less hard than trying to have government manage the fishery effectively.

Effects and impacts

[Section 3:]

The projects had been implemented with considerable dedication by the field teams and their leaders. The volume of activity, the number of groups of participants reached, the care with which activities had been carried out, and the willingness to adapt and change things when obstacles arose, were highly impressive.

Two factors seemingly explained this high performance. One was the sheer quality of the staff in the teams, both local partners and Canadians. The staff met were well above average in all grades, either experienced or highly qualified, or both — and imbued with enthusiasm for the project. The other was the support and encouragement given by IDRC staff who engaged closely with the work of the project teams, and helped facilitate whatever course corrections or additional activities proved necessary.

From the evidence available by May 2018, most activities in most projects had achieved what was intended — so far as that was possible to verify along the theory of change: in several cases that was only as far as behaviour change, rather than results and impacts.

Project teams had, for the most part successfully engaged with policy-makers. Mainly this was to inform them, to coordinate field activities with government services and programmes, and to raise the profile of the issues addressed by the projects and potential of the innovations developed.

Few projects depended on policy changes for success. In such cases, changes had been achieved, except for regulatory approval. Some projects needed the innovations pioneered to be approved by regulators, processes that proved lengthy and not complete by May 2018. Nevertheless, the prospects were approval were favourable.

Sustainability and scaling

[Section 4:]

Most innovations promoted by CIFSRF projects result in gain to private actors, be they households, farms or firms. It is thus reasonable to imagine that the project participants, and those input suppliers and traders they engage with, will have sufficient interest to sustain activity.

The main qualification is that private firms usually do not provide sufficient technical knowledge in the rural areas of low-income countries to address challenges such as pest and disease attacks. Hence public agricultural extension needs to complement private services if such challenges are to be overcome.

Just a few project activities have public good characteristics, and hence rely on public services to sustain them: nutrition education is the main example. In addition, public sources of technical information can usefully back up the innovations promoted.

Very few activities depended on collective action, the main and most important example being the management of river fisheries in the Bolivian Amazon.

Three projects depended on policy to sustain their efforts, requiring approval of their innovations from the regulators. In some cases approval has been delayed, but will probably eventually be granted.

If scaling up is taken to mean operating across most of the territory for which an innovation is appropriate, through agencies that intend to be longstanding, rather than temporary projects, then during Phase 2 most projects had only taken the first few steps to scale up. For the most part, they had advanced from proving a concept to developing a working model: a necessary, but not sufficient, condition for scaling up.

The challenges of scaling are simplest for innovations that are embodied in tools and products that can be provided privately, that can be readily applied by users, and which generate significant gains to users. The hexanal products of Nanotech for fruit are a good example.

Other innovations may confer private gains, but probably require some measure of public support in information and technical knowledge. Home gardens and intercropping would be examples.

Some innovations generate largely public goods, which are only likely to be provided at scale by public agencies. Examples are many of the messages in Bolivia Amazon fish, Cambodia homestead food, Ethiopia pulses, and Tanzania legumes.

5.2 Discussion

Three points arise that warrant further discussion: the successful implementation of CIFSRF; the relevance of the portfolio; and sustainability and scaling up.

What made for success in implementation?

From what could be seen by May 2018, the CIFSRF Phase 2 portfolio is a considerable success. As far as could be traced along the theories of change, albeit that for some activities that take time to achieve their results and impacts that was no further than behavioural change, most things that had been planned had been achieved. Falsification provides a useful test. A list of all the things that went seriously wrong in these 18 projects — most of these exceptions have been noted in the preceding sections — is quite short: perhaps half a dozen instances among more than 40 different sets of activities tried.

When Robert Cassen and his team pondered the success of development aid in the mid-1980s,[17] they noted three things, amongst others: that any development programme that had zero rate of failure would be a failure — nothing ventured, nothing gained; that the 65–75% of development projects rated satisfactory in their review was good, and probably compared favourably with the rate of success of private enterprise; and that agricultural development programmes were more challenging than most. (Cassen 1986) Taking these insights as benchmarks, CIFSRF Phase 2 has done well: only one of the 18 projects appears flawed owing to the assumption of an unworkable business model, Ghana ICT extension, and even that judgment may be harsh, the result of imperfect information.

An outstanding feature of CIFSRF has been the quite admirable implementation of the projects. Project teams operated with much effort, enthusiasm and thoughtfulness. The result has been projects that have a stellar quality to them, remarkable for the dedication and skill with they have been implemented. [18]

This prompts the question of why so many of the CIFSRF projects have been outstanding, to which the first draft reply notes the quality of project teams, both Canadian and developing world partners, and the support offered by IDRC. This review, not being concerned with the internal operations of CIFSRF or IDRC, can shed little further light on just how so many of the CIFSRF projects ended up with such talented and committed persons leading and implementing them.

The management of most formal bureaucracies — technical term, again — is reluctant to stress human factors: after all the very nature of role culture is that it is formal roles that count, not the individuals who occupy those posts at any given time. Yet when it comes to innovations, the importance of individuals has long been recognised. When Emery Roe, a development thinker and practitioner pondered what mattered in innovative rural development, he was minded to return to his native California and interview venture capitalists about which proposals they backed. Critical to their judgments was their assessment of the applicant and their ability to see the venture proposed through to conclusion. This trumped almost all other considerations. The venture

[17] Cassen's review looked mainly at the results of donor-funded projects. No comparable review has subsequently been written. The reason for that apparently surprising fact is that the mid-1980s marked the end of an era in which much development aid was disbursed in donor-led projects, often with expatriate management and using administrative structures additional to the government service. Subsequently, donors have preferred to support broader government programmes or to provide overall budget support.

[18] Development is not that short of such experiences. The better development agencies, frequently NGOS, often attract dedicated staff, inspired by the mission to alleviate poverty and help people transform their lives. Idealists, driven to improving the world, are much attracted by such work. For some kinds of development work, but by no means all, this dedication can make a difference. See, for example, Korten for examples of highly successful Asian development programmes. For a more recent example, see Smith et al. (2012) on the Shouhardo programme in Bangladesh, Spielman & Pandya-Lorch (2009) on successes in agriculture.

capitalists knew that if the project leader was not talented and committed, there would be no return at all on their investments. (Roe 1985)

If that consideration has been important in project selection for IDRC, then that has been wise.

A qualification applies here. It was clear from interviews with project staff that many of them had worked far longer and harder on these projects than was funded. That may well apply to almost any worthwhile research.[19] While few research funders could promise grants at the outset sufficient to cover most of what typically gets done in successful research, it does imply that funders should subsequently be prepared to authorise additional spending when justified in research that is proving successful.

Could the portfolio have been more relevant to food and nutrition security, or better targeted to the disadvantaged?

Impressive as CIFSRF Phase 2 has been, could it have been better? Could the projects have been more relevant, in content and participants?

The projects had much to commend them. The projects addressed relevant issues, focusing mainly on increasing food availability in pursuit of remedying dietary deficits in minerals, protein and vitamins. The projects have worked with people on low incomes, although not necessarily the poorest and most disadvantaged. More than half of project participants have been women.

So far, so good: but this prompts the question of whether the portfolio would have been similar had it been created by specialist judgment, as opposed to issuing calls for proposals from whoever was entitled to respond.[20] Had a panel of leading specialists on food and nutrition security been convened, to commission directly a suite of R4D projects, even with the important proviso that they draw on Canadian expertise, would they have generated a similar portfolio? Probably not.

Their portfolio might well have differed in at least two respects. One would be the degree of focus on nutrition. It would be hard to imagine a specialist panel with a food and nutrition security remit commissioning research into developing livestock vaccines or coconut disease, for example. It is not that these projects are not relevant to food and nutrition security. If they succeed in what they intend to do, they will no doubt help improve food and nutrition security. [So too, for that matter, might an assembly plant.] But they are not as closely focused on nutrition as, for example, the two fortification projects are — which might well have been chosen by the imaginary panel.

The other would be the focus within nutrition, where many nutritionists would probably have sought research to address the utilisation issues of child care, primary health, diet and hygiene, in addition to projects that focus on nutrition-sensitive agricultural development. Around half the CIFSRF projects, to their credit, included nutrition education as complements to their focus on agricultural production. As complements, however, using known technology, but not as innovations. A panel might have looked to have R4D projects that tested innovations in these dimensions.

Commissioning through public calls has the advantage that unexpected and potentially promising lines of investigation may be proposed. The drawback is that proposals are limited to the imagination of those who see the calls, have the time to respond to them, and are prepared to bid competitively for funds.

CIFSRF called for partnerships that helped apply Canadian expertise to food security. Most of the projects leaders from Canada came from a natural science or technology background, rather than being social scientists. That courted the danger of proposals being developed as

[19] The lead author currently helps support a portfolio of 19 studies of agricultural development, belongs to a couple of research consortia, and also edits a journal. Almost every piece of interesting research seen takes a year or more longer than planned, with researchers drafting key outputs long after funding has been ended.

[20] This is not to suggest that those evaluating the proposals were not specialised in food and nutrition security. The point is that they had to judge the proposals received, and presumably were not able to create alternative proposals.

technical solutions seeking problems, rather than vice versa. That risk, in the event, was very considerably mitigated by the way in which project teams then developed their projects, widening their scope to address problems whether or not initially favoured technologies were likely to be part of the answer.

Two examples make the point. In Colombia, the starting point was to breed improved yellow potatoes, by drawing on indigenous landraces and participatory variety selection. But this effort was subsequently complemented by a remarkably wide-ranging set of actions for food and nutrition security implemented in rural Nariño.

In Nepal, early hopes for applying Canadian expertise included a highly sophisticated technology to measure the effects of rhizobia on plant roots: cutting edge technology by any measure. By late 2017, this technology, however, had had little impact on farmers — which is not to say that it may not do so in the future. Instead, the partnership saw Canadians searching for items from the Ali Baba catalogue that might be applicable to terraces of Nepal, leading to some quite prosaic tools — gloves, rakes, for example — being tested in the field, some to considerable good effect.

Most projects targeted primarily by location of activities, looking for those where most people were on low incomes. Once locations were chosen, however, little further was done to target by social characteristics, other than to try and work with at least as many women producers as men. That invites the question of whether the projects should have tried more to identify and work more with disadvantaged groups within the communities chosen.

To repeat the argument from section 2.1.3, it would have been difficult to do so, and still have equally effective projects. To participate in R4D projects, households needed to have some resources — a little land, some labour, the ability take time to participate in groups and project activities. That may mean that the most disadvantaged in the community find it hard to participate actively. More pertinent, it is hard and risky for external projects to make such selections within communities, unless they know this has general consent from members of the village, and support — or at least acquiescence — from leaders. Projects that aim to raise production, as most of the CIFSRF projects did — especially the grow cluster — tend to be seen as a common resource, that should open to all in the community to participate.

What mattered more was that innovations were accessible to those with the least means in the communities. The projects that included multiple innovations, with Nepal terrace farming the outstanding case, had messages for almost all in the communities in which they worked.

How innovative were the CIFSRF Phase 2 projects?

When considering what the projects did, a wider question arises, about the degree of innovation promoted. While this question is intrinsically interesting, it underlies a more practical question that arises from the performance of the projects seen. Three projects were particularly ambitious in their technical focus: the avoid projects investigating applications of hexanal to fruit spoilage, and the two projects to develop heat-stable vaccines for livestock in Africa. If these are successful — and nothing to date suggests that they will not be — the potential gains could well be very high indeed. It would be surprising if a preliminary economic assessment did not estimate internal rates of return to the research of 20% or more. If those premises are reasonable, then it prompts the question of whether IDRC should have funded more of these technically ambitious projects, and fewer of the less ambitious ones.

To answer this question, we begin by looking at innovation in the CIFSRF Phase 2 portfolio. Technical innovation can be seen in two broad and related dimensions: the depth (intensity) and breadth of technical change; and the social and institutional change required to bring the innovation into use.

Much has been written about ways of considering the depth or intensity of innovation, see for example Coccia 2006, Chandy & Prabhu 2011. Schema typically distinguish between the nature of the innovation itself, and the effects it creates. One distinguishing characteristic of innovation, one that is particularly apt for this argument, is that of novelty. This may be seen in terms of conceptual novelty — does the innovation resemble something with which the user is familiar? And operational novelty — does

the operation of the innovation resemble activities with which the user is familiar?

In this dimension, the CIFSRF projects are quite diverse. At one end of the scale lie innovations that are either conceptually or operationally novel, or both, with the hexanal sprays of Nanotech for fruit the prime example. At the other end of the scale are those projects, almost all in the grow cluster, that deal in quite familiar technology, such as testing new varieties of known crops.

Similar large differences apply when considering the range or breadth of innovations[21] promoted. Nepal terrace farming promoted several dozen different technologies, of varying novelty and complexity. Another four projects also embrace a broad range of innovations, such as Cambodia homestead food, Colombia potatoes, India small millets, and West Africa vegetables.

Most of the rest of the portfolio, ten projects — almost all in the fortify and avoid clusters, are almost entirely concerned with testing and propagating a single innovation, such as Tanzania fortified sunflower oil.

The other dimensions concern social change — does the innovation require users to change their social roles, norms including those for gender, etc.? and institutional change — does the innovation require new forms of organisation of work and productive activity, mechanisms for governance, alteration of property rights, setting new product standards, creating demand for new products in markets, etc.? In these respects, most projects — 14 of them — involve project participants making relatively small, incremental changes to their current practices. By and large, participants either adjusted their current production methods; or changed to some crop or livestock that they either knew about, or which was similar to something they already grew or raised.

Only in a minority of cases did project participants have to master skills that were significantly novel, advanced, or both. These included the yoghurt processors of East Africa who had to include probiotics in their recipes and upgrade their processing; the millet processors in India developing new products from millet; and the potato seed growers in Colombia who had to learn to grow seed to exacting standards.

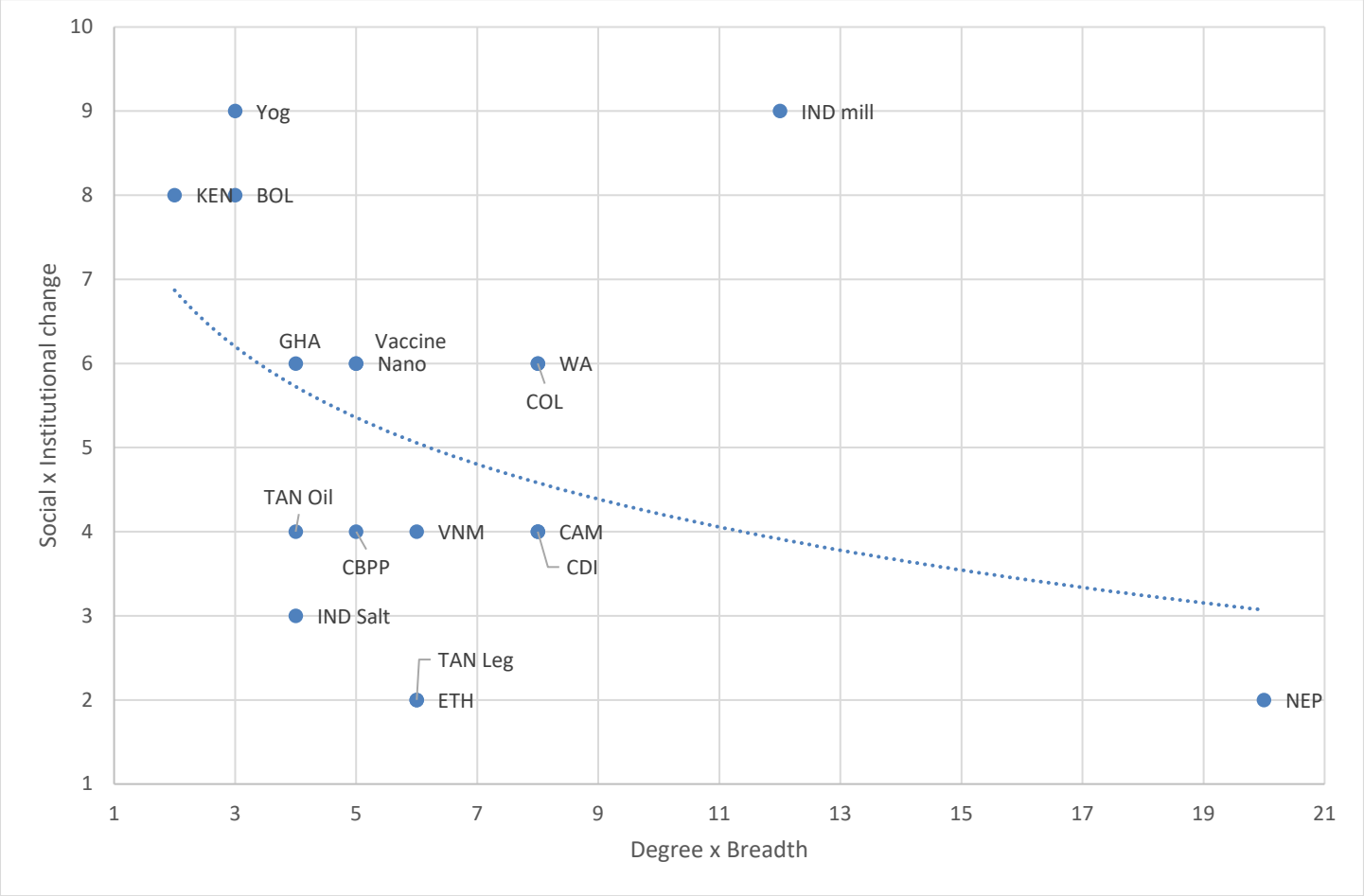
Institutional challenges have generally been stiffer than the social ones. Kenya farm shop pioneered a franchising model, with links to government extension workers; the *paiche* fishers of lowland Bolivia were expected to manage their waters collectively; and in Tanzania small-scale, rural oil processors needed to have the capital, will and discipline to add Vitamin A to their oil. Several projects required regulation either to approve their products, or to facilitate the innovation — Tanzania fortified sunflower oil, Nanotech for fruits, and the two vaccines projects.

An attempt was made to score the projects for the two dimensions and the four elements of them (Appendix D shows the scores); then the scores for depth and breadth were multiplied, as were those of social and institutional change, to produce overall scores for the two dimensions. Figure 5.1 plots these indices.

By and large, the technical challenges were greater than those that are social and institutional. Indeed, a weak inverse correlation (-0.30) could be seen between the depth and breadth of technical change attempted, and the social and institutional changes required. For example, Nepal terrace farming had a wide range of technical innovations, some quite advanced, but most of the innovations required few social or institutional changes. At the other end of the spectrum, the technical innovations for yoghurt processors were relatively straightforward, but the disciplines expected from the processors, and the creation of a market for probiotics, were much more demanding.

[21] Innovation in this paper is seen from the perspective of the user, not the developer. The latter may have to try several different, and innovative, methods to create a workable innovation. But for the end user, what emerges is a single innovation. The fortification of salt with iron is a case in point. It took repeated technical experimentation before iron could be added to salt that was stable, while the salt looked and tasted similar to any other salt. But for consumers, the fortified salt is a single innovation.

Figure 5.1 CIFSRF Phase 2 by technical and social dimensions



Note. Projects scored one to five for depth and breadth of technical ambition; for social and institutional change required. Technical and social scores multiplied, then plotted. Appendix D has details of scoring.

Three things appear from this, even if this classification does not produce the clearest of distinctions.

One is that more than half the projects — and most of the grow cluster — dealt in innovations that were low to moderate in their technical depth. To some extent, that sub-dimension traded off against breadth of innovation: scores were inversely correlated at -0.50. For the grow cluster, this made sense. Incremental changes to farming systems are more accessible to all farmers, but especially those with few resources, since they do not usually demand conceptual or practical leaps, or for participants to take significant risks. Offering a range of innovations respects the differences in resources, abilities and preferences found within groups of farmers.

Two, the two dimensions of innovations picked out here also traded off. That too was probably wise: innovations that are considerably novel both in their nature, as well as in their demands for social and institutional change are only likely to be adopted by most rural producers if they very evidently bring great benefits.

A longstanding critique in the literature on agricultural innovation is that scientists have tended to produce technically ideal innovations, rather than innovations suited to the circumstances of farmers, especially smallholders on low incomes. That has, for the most part, not happened in CIFSRF.

Three, with considerable diversity across the portfolio in these dimensions of innovation, it is likely that the conditions for sustainability and the prospects for scaling

up are similarly diverse. It does also suggest that it may be difficult to identify general lessons from the portfolio.

Can innovative models be trimmed so as to sustain and scale them up?

The nub of the challenge of sustaining efforts and scaling them up is this: pilot projects often achieve a great deal, but within restricted areas and with limited numbers of project participants, while using copious resources — especially the time of unusually talented and committed people. Efforts cannot be sustained with such resources: when pilots end, activities must survive with lesser support. Scaling up almost inevitably means undertaking activities with significantly less support per person engaged. Economies have to be made to working models.

For those wanting to sustain and scale up activity, that means assessing which parts of the project have been critical to success, and which have been useful complements, but not essential. The search is thus for more economical, stripped-down models.

More economical means often entail some loss of effectiveness, raising another awkward and demanding question: what can be lost in effectiveness, while still substantially delivering benefits?

In practice, judgments about what can be sustained and what cannot may be taken informally, dominated by considerations of what can be afforded within whatever budgets are available. But it would be good if a more considered and informed answer were to hand.

In this regard, documenting experiences from pilot phases, then assessing what was necessary would provide useful information for discussion. CIFSRF project teams have not been shy in producing documentation, but it is not clear how much of this addresses the critical questions of what constitutes the core of the innovations promoted, how they can be applied, with what results, and what is essential for their functioning.

Scope for more economic and financial analysis may exist: some was seen in the documents read, but not as much as could have carried out. Since most innovations have been designed to be carried out by farming households, or by small businesses, simple analyses of costs and returns, benefit-cost ratios, and returns to labour and capital would be useful. Further fairly simple analysis could then test just how much latitude there may be to make economies, and yet still have attractive returns.

5.3 Lessons learned

Regarding implementation of R4D projects:

1. For the success of R4D projects, **people matter.** CIFSRF has benefited from having highly effective partnerships and field teams, largely owing to the people who led and participated in project teams. Leaders and their teams need to be creative and flexible, resourceful and determined to operate learning processes successfully. For organisations funding research, these criteria should be explicitly sought among applicants.

   There may be scope to think more systematically about the CIFSRF field teams, asking questions about the relative performance of team members and their characteristics. What sort of things count more than others? Experience, advanced studies, enthusiasm, local knowledge and language abilities, social skills, etc.?

2. The requirements of some innovations for **approval by regulatory agencies** delayed their dissemination. Although the necessary tests and procedures take time, and may be hard to start before the innovation has been fully developed, where possible such procedures need to be started as soon as possible. The IDRC team is now well aware of this.

For sustainability and scaling up:

3. **Information can be pivotal**. Private incentives to innovate only apply if farmers, food processors, and those who work with them have reliable and convincing information about the innovations and how to make use of them. Market-led rural innovation requires plenty of information: some may be provided through dealer demonstrations and advice,

instruction manuals and advertising; but public information can support this with impartial advice.

For activities that require public services, convincing governments and donors to scale up pilots requires reports and evaluations that convince.

Collective action can be facilitated by information about models that have worked in other places, and about the processes that led to success — and about what not to do.[22]

6. Pilot R4D projects thus need to generate **reports and briefs** on what was done, achieved and how — together with what was necessary and critical to generate benefits, and what was not. Simple economic analyses of innovations, such as gross margins of enterprises, would be valuable.
7. **Time is needed** to develop working models fit for replication. While pilots can generate interesting and valuable results within two or three years of operation, refining these into working models that can operate at scale usually takes longer: a decade may be necessary. This particularly applies to agriculture which depends heavily on natural systems, vulnerable to external shocks: bad weather, for example, can invalidate a season's work. [23]

   The lengthy genesis of working models presents a dilemma for most donors, who are often reluctant to commit to more than five years of funding. Ways may be found to work within these limits, perhaps by considering how and when different activities piloted can be scaled up; to which answers may differ considerably by component.

   For example, innovations that convey clear private gains using techniques that are conceptually and operationally familiar to users, and probably embodied in a concrete product — think, for example, of a millet thresher, may require little further support once the innovation has been developed. On the other hand, innovations that are public goods, conceptually and operationally novel — for example, of integrated pest management — may need plenty of support before the innovation convinces farmers, agricultural advisers, senior civil servants and ministers, and so on.

   Funds and support might then be programmed accordingly, leading to assistance tapering earlier for some items than others, and allowing those that need more time to get the necessary longer-term support.

[22] Over-ambition is the curse of collective action, especially when that ambition spreads to functions that can be carried out individually. (See, for example, Curtis 1991, Wade 1987)

[23] Past experience gives some guide to the time necessary to scale up from pilots. The Amul dairy cooperative began in the late 1940s: it was only in 1970 that the model was sufficiently well developed and convincing for the government of India to roll it out across the Union. (Korten 1980) By and large, it worked: Operation Flood has been a major undertaking and a major success.

The green revolution was more than a decade in the making, from initial scientific research to plant breeding to testing and proving new high-yielding varieties that could be replicated. Their dissemination took another ten or more years. (Lele & Goldsmith 1989)

References and sources

Most of the information for this report comes from reading of project documentation, above all Project Approval Documents, recent Technical Reports and publications from the 18 research studies funded under CIFSRF Phase 2.

This synthesis also drew on reports on the six projects that were visited in the field:

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- Wiggins, Steve & Ricardo Vargas Meza, 2018, Expanding production of more nutritious yellow potatoes in Colombia, Overseas Development Institute

Three companion syntheses were drafted concerning specific results of the portfolio:

- Wiggins, Steve, Sharada Keats, Alex Löwe & Louise Shaxson, 2018, Understanding the CIFSRF Phase Two portfolio's contribution to generating income, Overseas Development Institute
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Appendix A List of CIFSRF Phase 2 research projects

Full title of research	Shortened version used in this paper
Amazon fish for food (Bolivia)	Bolivia Amazon fish
Scale up of Homestead Food Production for improved household food security and nutrition in Cambodia	Cambodia homestead food
Development of a subunit vaccine for contagious bovine pleuropneumonia in Africa	CBPP vaccine
Scaling up the production of more nutritious yellow potatoes in Colombia	Colombia potatoes
Fighting lethal yellowing disease for coconut farmers (in Cote d'Ivoire)	Côte d'Ivoire coconut disease
Fermented food for life (Kenya, Tanzania, Uganda)	East Africa yoghurt
Scaling-up pulse innovations for food and nutrition security in southern Ethiopia	Ethiopia pulses
Achieving impact at scale through ICT-enabled extension services in Ghana.	Ghana ICT extension
Scaling up the production and distribution of Double Fortified Salt in India	India salt
Scaling up small millet post-harvest and nutritious food products (in India).	India small millets
Farm Shop — Scaling Access to Agricultural Inputs in Kenya	Kenya farm shop
Enhanced preservation of fruits using nanotechnology	Nanotech for fruits
Nepal terrace farmers and sustainable agriculture kits	Nepal terrace farming
Novel livestock vaccines for viral diseases in Africa towards improved food security	Novel livestock vaccines
Promoting locally fortified sunflower oil using e-vouchers (in Tanzania)	Tanzania fortified oil
Scaling up improved legume technologies in Tanzania	Tanzania legumes
Scaling up small-scale food processing for therapeutic and complementary foods for children in Vietnam,	Vietnam therapeutic foods
Scaling up fertilizer micro-dosing and indigenous vegetables production and utilisation in West Africa (Nigeria and Benin)	West Africa vegetables

Appendix B Results observed in each project

B1 Nutrition

Project	People reached	Contributions to improved nutrition
Bolivia Amazon fish Increased availability of fish for home consumption among low-income consumers. Nutrition education on benefits of fish. Improved incomes for participating households, allowing for improved, diversified diets.	River fishers, fish farmers in Bolivian Amazon and consumers both local and national. Estimated 1,030 families directly reached by the project across 40 communities (1,757 with other municipalities) 379 indigenous fishers, 32 other fishers applied good practices introduced by the project	Fish consumption is increasing in fish farming families, and the general public. Increased incomes for indigenous farmers allows for improved family diets. Workers on fish processing farms are able to use fish fat in home baking and cooking. Potential significant impact in areas of Bolivia with high rates of low income households that report poor nutrition. Main pathway probably that of income leading to food access, rather than the benefits of eating fish.
Cambodia home gardens Increased home garden and fish production leading to more diverse diet, richer in micro-nutrients and protein. Some value-added processing. Nutrition education on diets, water, sanitation, child feeding, hygiene	Farm families in rural areas, their neighbours and shoppers in their local markets, in three provinces: Kampot, Kampong Cham, Prey Veng; and one district of Phnom Penh. Estimated 19,440 individuals reached with more diverse / better diets.	Project participants (3,888 households, est. 19,440 individuals) have improved / diversified their diets. Reports of more exclusive breastfeeding, use of water filters, more handwashing. Reports of improved health of children Study in phase 1 showed the proportion of women with high dietary diversity scores increased from 7.7% to 36.8% during the 22 months of participation. Project may be scaled out across more of Cambodia. Strong potential to replicate further across countries where Helen Keller International operates elsewhere in Asia, and in Africa – and beyond
Colombia potatoes Dissemination of new varieties of yellow potato with enhanced protein, micro-nutrients Distribution of micro-nutrients powders Promotion of collective and individual home gardens	Rural households, five municipalities of rural Nariño plus consumers across Colombia more widely. Estimated to reach 6.5 million consumers by March 2018.	Three varieties of improved yellow potato available to 6.5 million consumers by March 2018. Dietary diversity and food security improved with increased production and consumption of fruit and vegetables. After implementation of Shagras para la Vida (among 500 smallholder home gardeners), number of households classified as food insecure decreased (81% to 41%) while the number of households classified as food secure increased (19% to 59%). Reported diet diversity scores increased from 18% to 53%. 70% of the 200 households participating directly in the project improved their nutrition and health, learned proper eating and nutrition habits, recovered some ancestral foods. Lessons in hygiene/ care of children likely to produce significant effects. Significant potential exists to expand the current production and consumption of the improved potatoes further (cultivated area now accounts for 16% of the total cultivated area of yellow potatoes).

Nutrition education on child feeding, hygiene, food preparation diets, ancestral knowledge		National potential for Colombia, and possibly expansion to other countries in the region and beyond
East Africa fermented food Increased production of yoghurt to improve dietary diversity; replacement of less hygienic yoghurts with those produced to better food safety standards. Nutrition education introducing people to probiotic yoghurts (PY) which improve gut health, and contributing to more diverse diets rich in micronutrients	Consumers in several districts of Kenya, Uganda, and Tanzania. Consumers in three countries, some regular consumers estimated to exceed 203,000.	Health benefits of PY and other fermented foods have been documented, including weight gain, fewer skin rashes, reduced diarrhoea. In Kenya: PY regularly consumed by 300 children in 3 orphanages, probiotic porridge (PP) by 1200 children in 20 early childhood development centres. 18 production units produce 3,700 litres of PY per week. Regular consumers of PY estimated at around 5,000 (assuming 250ml / day / person, 3 days/week) In Tanzania: 84 production units produce 14,733 litres per week. In Uganda: 116 production units are producing 25,947 litres per week. Consumers estimated to number 200,000. 63% of the 200 production units in Tanzania and Uganda are female owned, and 60% of the 945 people involved in the business (e.g. production, distribution and marketing) are female.
Ethiopia pulses Improved production of pulses to combat protein deficiency among over 70,000 rural households. Nutrition education around child feeding, healthcare	23,059 farming households reached through nutrition education, resulting in increased dietary diversity 51,068 farmers reached with extension messages, improving access to protein in those households 35,000 consumers using pulse-based complementary food products	People are producing and consuming more pulses with improved cooking techniques. 51,068 farmers reached (42% female), with 3,324 organised into 665 seed producing clusters. 23,059 members of farming households have benefitted from nutrition education, cooking demonstrations and skills training for mothers (99.3% female). More than 35,000 consumers used ready-to-eat, pulse-incorporated complementary food products. Children are being treated in health centres. It appears that considerable increases in protein consumption and a concomitant reduction in calorie-protein malnutrition could be achieved. Improved pulse production can easily be scaled-up further through extension service. Farmers are also sharing knowledge and seeds. Private sector is producing and marketing pulse-based snacks and complementary foods. Improved mother and child nutrition through preparation of pulse-based recipes and complementary feeds for children Possibility exists to further scale up nationally the improved mother and child nutrition through preparation of pulse-based recipes and complementary feeds through adoption of curriculum by Ministry of Health
India double- fortified salt (DFS)	Estimated to reach approximately 50 million consumers by mid-2018 in three	Reached approximately 25M beneficiaries by early 2018, expected to increase to around 50M by mid-2018 as distribution through PDS continues through three states: Uttar Pradesh, Madhya Pradesh, Jharkhand).

Reduces iodine deficiency Reduces iron deficiency and hence less anaemia Consumers made aware of benefits of DFS	Indian states: Uttar Pradesh, Madhya Pradesh, and Jharkhand.	Strong potential to reach millions more people if DFS goes country-wide across India. Strong potential for countries outside India to regulate for use of DFS
India small millets Small-scale millet dehullers are being produced and sold. Micro, small, and medium enterprises are producing and marketing more millet-based foodstuffs, improving incomes that allows them to improve own diets. Large numbers of consumers are eating more millet.	Consumers of small millet foodstuffs – approximately 550,000. Small-scale producers of small millet foodstuffs in Tamil Nadu and other Indian states.	Over the project, 210 tonnes of value-added products and 1,015 tonnes of bulk small millets have reached 550,000 consumers. Target beneficiaries on low incomes report eating more millet, feeding their children more millet, and feeling healthier (better blood sugar control); but impacts and attribution not clear. For women in rural communities switching to dehulling millet by machine instead of by hand to save time and effort may improve food security outcomes of dependants through for instance more time for infant care. Plenty of unmet demand for small scale processing machines across India. Constant innovation by manufacturers. Scope among existing enterprises to supply larger markets, diversify products Potential to replicate the model more widely or scale up via inclusion of millets in PDS, school feeding schemes.
Tanzania fortified oil Increase intake of vitamin A and reduce vitamin A deficiency Nutrition education about benefits of vitamin A.	Up to 500,000 people reached (project estimate) BCC campaign reached just shy of 100,000 people (project estimate)	Over 140,000L of fortified oil was produced by SMEs and purchased by consumers, increasing vitamin A consumption for 645,772 consumers. Blood retinol levels increased in the intervention areas, with the most likely explanation for this being the consumption of fortified oils by consumers (Horton et al, 2017). The project has proven that crude sunflower oil, most consumed by the poor in rural Tanzania, can be fortified with vitamin A, and if the project is taken up again, greater numbers might be reached sustainably.
Vietnam therapeutic foods Production of therapeutic and complementary foods that are consumed by young children, improving their dietary diversity Nutrition education on child feeding, health and hygiene through counselling	Young children in three northern provinces of Vietnam. Approximately 29,000 children under two.	Mothers of 22,248 children under 2 years received nutrition counselling and were encouraged to purchase ready-to-cook nutritious complementary food made from local produce and enriched with iron and zinc to fill the dietary gap in these essential nutrients. 2,550 pre-school children in 10 kindergartens received 2,899 kg of complementary instant porridge snacks over 4 months.

West Africa vegetables Increased production of micronutrient-rich indigenous vegetables (IV) on many small-scale farms, with reduced seasonality, leading to higher consumption of micronutrient-rich vegetables. Young-Vegetable-Scientists' clubs set up to encourage healthy diets in teens Prisoners producing indigenous vegetables to earn extra cash.	Rural households in Benin and Nigeria. 337,931 farmers reached in total.	Project reached a total of 337,931 farmers (50.6% female) in 36 months. 229,750 in Nigeria (51.6% female); 108,181 in Benin (46.3% female). Project has effectively surpassed target number of 255,000 farmers planned for the period. As well as more production and consumption of IV, seasonality of indigenous vegetable production has been reduced (more year-round production, post-harvest technologies to dry products), meaning people can consume them more often. Changes to nutritional status expected. New recipes for vegetable-fortified foods developed. These show improved nutritional and health-promoting values (significant increases in protein, vitamin C, and minerals) Progress made in extraction & identification of bioactive compounds, especially polyphenols, antioxidants linked to e.g. reduced cancer Seed systems are being set up, post-harvest technologies have low operational cost/maintenance, high ease of use. Strong potential to further scale up vegetable production, especially area of land devoted to IV, as well as further processing and marketing in Nigeria and Benin.

B2 Sustainable agriculture

Elements of increased agricultural productivity	People reached	Contributions to increased productivity
Agricultural improvement through groups of farmers		
Colombia potatoes Teaching potato seed production of improved varieties to potato farmers. Encouraging home gardens for improved potato production to rural households.	2,490 farmers directly benefited (1,223 men, 1,267 women); 1,845 children (1,336 boys, 1,509 girls), 5,000 shagras families & home gardens Indirect beneficiaries: 885 male & 686 female farmers Smallholder groups growing seed potato, 133 growers Smallholder home gardeners, 500 households	Cultivated area of 734 ha for maincrop potatoes, 16% of total cultivated area for yellow potatoes Certified seed tuber yield raised from zero to of 20t/ha. Accumulated production over the project totals 2,612 tonnes of seed tubers of new potato cultivars across 7 regions, with 335 tonnes for consumption. Projected consumption of yellow potatoes by 8.6 million people in 2018. 87% of farmer field school participants reported a reduction in agrochemical use, 62% adapted soil protection practices, 50% followed safety measures when handling agrochemicals, 54% established an orchard. A total of 160 shagras and home gardens were advanced, that prioritized organic agriculture practices and preserved and recuperated native genetic resources.

	The Project's three new yellow potato cultivars are currently available to 6.3 million Colombian consumers.	
Cambodia homestead food Improve management of ponds for fish production. Increase availability of fingerlings on local markets. Production of vegetables in home gardens.	Project participants (3,656 households, estimated 17,500 individuals) have improved / diversified their diets	10 hatcheries established. Hatchery in Kampot selling 10k fingerlings/month. Other hatcheries report similar production levels. At least 4,500 home gardens in three provinces Increase in households with home gardens from 54% at baseline to 83% in final survey. 83% have adopted improved production techniques and new technologies. Data on projected productivity is not available.
Nepal terrace farming Improved varieties, planting techniques and new technologies, to be adopted and adapted by farmers to suit individual needs.	Smallholders in hill villages with terraced land growing diverse crops: 270k smallholder farmers reached in total, of which 26k households have purchased at least one sustainable agricultural kit (SAK) product 1,057 farmers reached directly with selected agricultural practices of which 74% are continuing to use them. In total 5,291 farmers have tested, and 4,508 are directly using, one or more of the recommended practices. Agronomic trials in 678 farmers' fields 1,986 households from outside the test sites are undertaking SAK practices, partially supported by the project or other institutions.	Increased vegetable production and consumption by 26% Legume yields increased by >25%; 0.43 tonne/ha yield increase of high-protein grain. Legume production (40kg/household) in previously unused terrace walls. Yield per ha increases from intercropping: • Maize-cowpea: 26% • Millet-soybean 26% • Mustard-pea: 30% 86% of farmers who tested intercropping will continue.
Bolivia Amazon fish Capacity building, credits & marketing support to increase *paiche* production. Fisheries law and organisational strengthening processes support	1,030 families directly reached by the project across 40 communities (1,757 with other municipalities) 379 indigenous fishers, 32 other fishers applied good practices introduced by the project	Fish farming: productivity increases to fish farming rose 57%: from 2.8 to 4.4 tonnes/family/ year. Total production rose from 811 to 4,805 tonnes/ year in the core region of 5 municipalities (455% increase). Number of ponds/producer rose from 3.4 to 4.6, increasing production to 5,114 tonnes/producer Fishing: *Paiche* production rose from 305 to 724 t/year (137% increase). Expected to rise to 1,200t/year (294% increase)

better fisheries management and new fish leather value chain created to utilise fish skin (i.e. the whole fish rather than simply the meat).	Approximately 20 fish farming families added one new pond or more Fish vendors, artisans (fish leather crafts), restaurants About half fish farming participants are women.	8400ft² of paiche leather produced (from zero base).
Ethiopia pulses Demonstrating value of pulse production, teaching new techniques and use of technologies (including use of inoculants).	Smallholders growing pulses: 51k farmers reached (42% female) with improved varieties and farming techniques, 665 seed producing clusters organised (3,324 farmers), 9 seed producing cooperatives established (3 women cooperatives). Guts Agro processes chickpeas to snacks: has women vendors.	Increase in yields from 1,000 to 3,200 kg/ha for chickpeas (220% increase). Bean yields in the range of 2,900 and 5,000 kg/ha, compared to 1,100 and 3,000 kg/ha for local varieties (increases of 164% and 67% respectively). NB it is unclear whether these yields are being achieved by farmers or only in variety testing.
West Africa vegetables Fresh leaf vegetables produced using microdosing technologies to increase yield.	Smallholder vegetable farmers: 338k, 51% women. Vegetable traders: 21k. 65% women in Nigeria, 72% in Benin. Processors: 315 Nigeria, 67% women; 9k in Benin, 95% women Seed growers and sellers: 576 Input dealers: 402 Students reached with extension and nutrition messages: 68,000 in Nigeria (46% female), 30,157 in Benin (4% female). 881 teachers trained in Nigeria, 76 in Benin	Fresh leaf yields of microdosed vegetables increased 46–57% compared to control groups. Land area under vegetable production in Benin project area increased by 161% (from 985 to 2,575 ha). Land area dedicated to microdosing is 280 ha. Land under vegetable production in Nigeria project area increased by 768% (from 9,105 to 79,110 ha). Land area dedicated to microdosing is 356 ha. Radio programming has the potential to reach 10 million listeners.
Agricultural improvement through extension		
West Africa vegetables	As above	As above

Kenya Farm Shop Providing extension advice and improved inputs through agrodealers.	74 franchised agricultural input shops, with 50% owners women, 54% assistants women Farm Shop served 35,000 smallholder farmer customers (54% women) 15 more shops being franchised at Feb 2018 26,600 smallholder farmers trained, (52% women) through 59 village demonstration plots. 21 shop assistants, 29 franchisees, 18 Farm Shop staff trained	731 farmers directly trained, though uptake and impacts of individual trainings not recorded in project documentation. Communities with a Farm Shop realised a 13.4% increase in milk production over those in communities with no Farm Shops—directly correlated with attending Farm Shop trainings. No data for other crops or livestock.
Ghana ICT extension Teaching land preparation, weed control, crop spacing, pesticide use, adoption of improved seeds through various information and communication technologies (radio programmes, linked to mobile-enabled extension agents)	The project has reached 500k farmers across 6 rather than 3 regions (486k reached by radio, 14k reached through mobile-enabled agents). The project engaged 6 radio stations and aired 575 radio programmes; trained 264 buyers and 234 buyer agents; and provided information on 5 crops (maize, rice, cowpea, yam, soya). 243 field agents were trained and are using the SmartEx technology, and 13,299 farmers registered for their services.	Adoption rates amongst those who interacted with mobile-enabled extension agents indicated 93% for land preparation, 87% for weed control, 81% correct crop spacing, 54% for use of pesticides & improved seed. 75% of women interviewed applied an improvement. Among radio listeners, average maize production per farmer rose from 919kg to 2208kg (230% increase). Yield differentials for listeners and non listeners were 2.25 vs 0.99 mt/ha for maize and 2.39 vs 1.95 mt/ha for rice. Average yield/ha increased by 16% (unclear whether this relates to all crops or just maize). Willingness to pay studies show that 82% of non-participants and 94% of participants in AgroTech SmartEx services would be willing to pay GHC30-40/acre/ season 500k farmers reached through radio, while 175k have adopted or used some of the promoted practices or technologies. That leaves 325k who may still adopt some of the technologies or practices. However there are doubts about the financial model that has been proposed as it requires a large up-front investment.
Tanzania legumes Teaching improved planting techniques via radio and other extension services. Training on incorporating residues when preparing land, use of improved varieties of common bean and soya bean, spacing, weeding, use of fertilizer with common bean, use of inoculant with soya bean, use of PICS (Purdue Improved Crop Storage) bags – hermetic storage	Smallholders: 600k reached, mainly through radio; 129k farmers adopted at least one technical innovation. Training farmers in improved agricultural techniques (32 demonstration plots across N and S Tanzania over 2 years with up to 1,682 farmers (977 men, 705 women) attending training days, with an estimated 19–20,000 influenced by the training days). 75 agricultural input dealers reached. 14 Hub agro-dealers (12 men and 2 women) and extension staff (17 men and 5 women)	Project produced >30 tonnes of certified seed and 24 tonnes of basic seed of promoted varieties. Farmers report increased yields for improved pulse varieties. Yield data not available. Project estimates potential listenership of up to 8 million farmers.

bags to prevent weevil/pest damage and aflatoxin)	were trained on improved seeds and good agronomic practices for legumes. 341 rural agro-dealers and extension officers at retail level were trained on improved seeds and technologies	
Reducing losses and spoilage with cutting-edge science		
Côte d'Ivoire coconut disease Research on disease to control and mitigate effects of Cote d'Ivoire Lethal Yellowing disease on productivity of coconut trees.	Smallholders with coconut groves: 10 field schools, 6 women's groups (173 members), 9 plant clinics, 8 Women's Coconut Fairs	Disease- affected coconut trees yield no more than 15 nuts/year/tree. Healthy trees yield 104 nuts/tree/year (593% increase), 240g copra/nut, and 3.5 tonnes of copra/ha/year (though it is unclear whether this has been achieved by farmers or in test sites) Improved techniques (application of poultry manure) can decrease impact of CILY by a half. (Infection rates are 85% in CdI). Future impacts on productivity at farm level not projected
Nanotech for fruits Extending shelf-life of fruit (mangoes, oranges, banana) to reduce post-harvest losses and reducing pest attack to reduce pre-harvest losses through nanotechnology.	India: farm advisory services offered to 4,360 farmers (81% defined as small or marginal farmers, 32% women), 2,000 model farms established in Tamil Nadu with 3 knowledge hubs. Over 2,000 farmers directly informed, an additional 25,000 farmers reached through farmer-to-farmer dissemination. 16 training sessions in value addition (i.e. making jams and pickles) for post-harvest entrepreneurs reaching women (360) and men (90) Kenya: unclear how many farmers have been reached	India: EFF spray reduces losses by up to 10% in mangoes and can extend the harvest period by 14–21 days in a range of fruits, which allows farmers to spread their marketing activities and benefit from premium prices later in the season. Cost: benefit ratio per tree calculated to be 1:5. Kenya: EFF spray improves on-tree fruit retention of by 13–14 days per season, reduces fruit drop of sweet oranges by up to 50% (45.4% in mango) Tanzania: EFF spray reduces fruit drop in mango by 40% with reduced pest attack Global: post-harvest dips extend shelf life of a range of fruit by 12-18 days depending on fruit, reduces disease incidence by 80%. Nano stickers also extend shelf life of mango & banana by 12-18 days. Project has not estimated long-term uptake, but it could be very considerable indeed. No challenges to the widespread rollout have been foreseen: in the review team's assessment, the project could benefit millions of small scale fruit farmers and associated packers/shippers.
Novel vaccines for livestock Vaccine to reduce livestock loss and increase productivity per animal.	Small animal livestock owners and their communities in Kenya and South Africa	Project has yet to conduct efficacy and safety tests to inform robust projections. However, estimated global annual losses from Peste des Petits Ruminants alone are of $1.4–2.1 billion. Even a 10% reduction in losses would represent a $14m annual gain.
Africa CBPP vaccine	Bovine livestock owners and their communities in Africa	Project has yet to conduct efficacy and safety tests to inform robust projections. However, with mortality rates of up to 80%, the potential gains from a successful vaccine are very considerable indeed.

Vaccine to reduce bovine livestock loss and disease to increase productivity per animal.		

B3 Income

<table>
<tr><th>Project
Means to raise incomes</th><th>People reached</th><th>Degree of gain</th></tr>
<tr><td>Ghana ICT extension
Increased production by smallholders, mainly known crops</td><td>Project reached 500k farmers across Ghana.
175k adopted at least one improved technique.</td><td>Differences in yields seen between radio listeners participating in project and those not participating:
<table>
<tr><th>Yield: tonne/hectare</th><th>Maize</th><th>Rice</th></tr>
<tr><td>Radio listener participants</td><td>2.25</td><td>2.39</td></tr>
<tr><td>Non-listeners</td><td>0.99</td><td>1.95</td></tr>
<tr><td>Difference</td><td>0.26</td><td>0.45</td></tr>
<tr><td>Value, US$</td><td>75</td><td>177</td></tr>
</table>
Prices: Ghana Esoko Sept 2017: GHC 288.3 per tonne maize; GHC 452.7 per tonne (milled) rice. Rice conversion at 70%. GHC$4.40 = US$1
Maize yields up 230%, reports by participant famers, by 1.3 tonnes per hectare in total: an additional 1.3 t/ha would be worth US$418 [Ghana Esoko prices]</td></tr>
<tr><td>Kenya farm shop
Farm shop owners earn profits through more efficient and less risky operations; assistants earn wages
Farmers access good quality inputs and equipment, together with training; raise yields; increase income</td><td>74 franchised agricultural input shops, with 50% owners women, 54% assistants women
15 more shops being franchised at Feb 2018
26.6k farmers trained, 52% women through 59 village demonstration plots</td><td>Reports of improved shop sales and returns; increased production and better returns for farmers, but no specific statistics known.</td></tr>
</table>

East Africa fermented food Processors gain from less waste, improved product, with novel addition of probiotics, with more sales Promotion of yogurt with probiotics to consumers	Small-scale yoghurt processors. By 2017–18 in Kenya, Tanzania & Uganda, nearly half of them women.	In Uganda: Profit from selling one litre of probiotic yoghurt is at least 3 times the profit of selling one litre of fresh milk; Income gains of selling probiotic yoghurt instead of fresh milk is on average US$95 per production unit per week. In Tanzania: Income gains of selling probiotic yoghurt instead of fresh milk is on average US$193 per individually-run production unit per week
Bolivia Amazon fish Fishers manage fisheries better, utilize fish meat and skin — new value chain for leather, increase yields Fish farmers raise more fish more efficiently, increase yields More fish means more jobs in supply chain for traders, retailers, eateries, fish leather works Value chain development	River fishers, 379 indigenous, 393 commercial. Affects 630 households in 40 communities reached. Fish farmers, 335 households in 12 associations Fish vendors, artisans (fish leather crafts), restaurants About half fish farming participants are women	**Fishers:** 379 indigenous fishers increased their income by 47.5% through meat sales and 32 indigenous fishers improved income by 23% through skin sales (for leather) 393 commercial fishers improved income by 35.5% through meat sales and 5 commercial fishers improved income by 23% through skin sales 56 vendors (retailers) improved income by 28% from fish meat sales **Fish farmers:** 335 families, in 12 associations 72% of fish farmers consider their income has increased by 50%–100%; 52% claim 50% increase. 2015, producer families from core region made an average of US$7,705 a year; while by 2017, gross average income had risen to US$ 19,079, an increase of 148%, [household survey data]. Growing local economy, currently valued at approximately US$4.5M annually in gross sales of fish. Additional associated economic benefits seen in the region, for suppliers, restaurants, and tourism businesses. **Processors, transporters, traders, input suppliers** Gains to *paiche* leather tanneries and crafts, to fish pond input suppliers, to transporters and traders trained and guided by the project
Nanotech for fruits Less fruit spoiled in field and in supply chain Marketing season extended Improved production through training	Fruit growers: 12k in India Packers & shippers	India: farmers report premium price gains of 15–18% India: income gains to fruit packers of Rs19,000 [US$295] per tonne of fruit from post-harvest biowax dips. Overall income gains of 10-15% depending on crop. Mango farmers: extra income per acre, US297, plus US$220 from longer harvest period and shelf life, plus US$156 from increased yield due to high retention. 24% rise in income overall

New product: banana stems sold for fibre making		Adoption of improved post-harvest management practices created 12–17 days additional employment per harvest season for women. Post-harvest value added increased household income by Rs240–270 [US$3.70–4.15] per month. In Sri Lanka, growers benefited from selling banana stems for fibre, worth US$150 an acre.
Ethiopia pulses Better seeds and techniques for pulses leading to higher yield, increased production, increased sales. Production in off season Processing of chickpea to snack food	Smallholders growing pulses: 51k farmers reached (42% female), Smallholder seed growers Guts Agro processes chickpeas to snacks: has women vendors	Farmers report higher incomes from pulses. Project research in Sodo and Wolayita districts, chickpea farmers earned an extra Birr3,500 [US$152] Women involved in sale of Guts Agro produce increased their incomes
West Africa vegetables Increased production of existing and revived indigenous vegetables, through micro-dosing and other techniques Intermediaries trained in business skills. Processing of vegetables, addition of green veg to bread and other foods	Smallholder vegetable farmers: 338k, 51% women Vegetable traders: 21k. 65% women in Nigeria, 72% in Benin. Processors: 315 Nigeria, 67% women, 9k in Benin, 95% women Seed growers and sellers: 576 Input dealers: 402	Increased output of vegetables, with prices up 35–65% owing to marketing drives Vegetable production based on 0.5ha land area resulted in a net benefit of US$3,879 and US$3,650 in Benin and Nigeria, respectively Osun Government Youth Empowerment Scheme (OYES), farmers report profits from sale of indigenous vegetables of up to 300% of investment. Youth groups generated an average of US$2,197 in Nigeria, US$2,428 for Benin Vegetable traders: 120% rise in revenues for Nigeria, 90% for Benin. Benefit-costs ratios of 1.42–2.35 Nigeria, 1.22–1.32 for Benin.
India small millets Technical improvements to equipment increased demand, sales Better processing for improved products with more demand and higher prices Support to small businesses	Equipment manufacturers: 5 Food processors: 814 Vendors of millet porridge: 152	Significant for machinery producers and food processors More income and employment for women in processing **Millet porridge vendor** husband-and-wife team selling from a cart to low-income customers earned net incomes of Rs280 a day, or US$4.27. Millet products sold to middle class consumers, run as a side-business by a farming family reported monthly sales of around Rs60,000 to 70,000, with margins of around Rs15,000 rupees, or US$7.70 a day. Their turnover three years ago was around half this amount.

Lobbying for through higher Minimum Support Price (MSP) for small millets, regular procurement of miller by government		
Cambodia homestead food Improved fish management to boost production Increased output of vegetables, fish — some of which is sold micro-credit support to women so they have a greater financial stake in EHFP leading to more successful farmers.	Fish nurseries and hatcheries Rural households with home gardens and fish ponds	Substantial for hatchery and nursery operators Small gains for home garden and pond operators. Over 2 months prior to survey, sales earnings rose from US$0.99 to US$10.15 for vegetable growers; from US$2.47 to US$22.71 for those with fish as well. [Annual equivalent increases of US$55 and US$122] Earnings very largely in the hands of women.
Nepal terrace farming Improved technology either boosts yields or saves labour Increased sales of seeds, inputs	Smallholders in hill villages with terraced land growing diverse crops: 1,057 tested innovation, 782 adopted at least one; 924 farmers reached through farmer-to-farmer extension, 2,137 other farmers have learned of innovations. 56k farm households have bought one or more of tools, equipment and seed kits promoted by project Retailers of seeds, tools	Several innovations generate more cash income from higher yields or use of previously unproductive land, such as terrace walls. Extra production used partly for home consumption, but some sales generating small amounts of <US$50, valuable since often to women, off-season. Terrace wall crops: yams, US$5 sack; chayote, US$54 per plant; pumpkin US$54 per plant Terrace edge crops: rice bean. US$14 from 7kg harvest [Kaski], US$19 from 10 kg harvested [Dhading] Cow peas, black gram give similar returns Intercropping: increases in economic returns: maize-cowpea 64%; millet-soybean 154%; mustard-pea 30%; wheat-pea, 30%; ginger-maize-soybean, 11%. Average ginger crop 56kg worth US$29 Poly tunnels with drip irrigation growing tomato and other high-value veg can generate gains net over costs of equipment of US$ 200 over 6 seasons/3 years for a 50 square metre covered garden.
Tanzania legumes Improved cultivation of legumes leads to higher production, more sales	Smallholders: 600 k reached, mainly through radio; 129k farmers adopted at least one technical innovation Agricultural input dealers: 75	No income data Access to output markets for soy bean has been patchy, some smallholders were left with unsold produce. Pigeon pea prices collapsed after India, the main export destination, imposed an import ban in August 2017 [apparently rescinded in May 2018].

Rural dealers in agricultural inputs trained in technology and business skills with potential for increased earnings		
Côte d'Ivoire coconut disease Disease control will increase yields for participating farmers, should lead to increases in income. Training farmers for alternative income earning activities	Smallholders with coconut groves: 10 field schools, 6 women's groups (173 members), 9 plant clinics, 8 Women's Coconut Fairs)	No systematic evidence to demonstrate increases in income. Successful disease control will increase yields for participating farmers, which should lead to increases in income. Gains to disease control depend on what would otherwise have happened. Growers whose trees suffer severe attacks from coconut disease may then prevent large income losses. Alternative income-generating activities, especially for women, should also raise income
Colombia potatoes Farmer groups trained to become seed potato growers with commercial enterprise Campaigns to promote demand for new potato varieties Promotion of home gardens that allow some sales of veg, fruit	Smallholder groups growing seed potato, 133 growers Smallholder home gardeners, 500 households	4 of 5 seed grower groups (NER) have generated returns of 16% or more: just one was struggling to contain costs. Material benefits for those with home gardens mostly in the form of fruit and vegetables for domestic consumption, although 64% of ECAF participants reported increased incomes. One ECAF group has formed a credit union intended to raise incomes.
CBPP vaccine & **Novel vaccines** Less disease, fewer losses of stock and production, increased output	Livestock keepers across much of Africa, potentially in other continents as well	Potential for large income effects to keepers: the death of livestock can be catastrophic for households on low incomes. Loss of output to surviving stock can be significant.

Appendix C Considerations for sustaining activities started under CIFSRF Phase 2

Very likely to be sustained, scaling very likely or already underway	Probably will be sustained. Good prospects for scaling	Activities will be sustained, provided some challenges can be overcome	Not clear how it will be sustained: formidable challenges evident

	Private gain	Public services	Collective action	Policy
Bolivia Amazon fish				
River fisheries management	Fishers have strong incentives: *paiche* are very large and valuable fish	Support to fisheries collectives: technical assistance, plus encouragement needed. Not so clear where this will come from	Stiff challenge to manage rivers collectively. Social discipline key. Degree of challenge likely to vary by community	[Policy for fisheries management in place]
Fish ponds	Pond owners have incentives, as do suppliers of fingerlings, feed and other inputs	[Technical assistance may in this case be provided by input suppliers]		
Fish leather tanning and leather crafts	Both activities look profitable. Quality crafts should find niche markets	[May need some technical support, but probably not public support]		
Cambodia home gardens				
Fish hatcheries and fish nurseries	Strong incentives from profits, high and growing demand.	Fisheries Administrative Agency is likely to try and replicate model further across Cambodia		

	Private gain	Public services	Collective action	Policy
Village model farmers (VMF)	Moderate potential to improve incomes a good incentive	NGO support may not be necessary for existing VMF, but would help for enrolling new ones/ scaling up Improvements in gender relations likely to require further NGO support		
Home gardeners	Small but significant increases in incomes. Noted improvement in child health likely to sustain improved feeding / hygiene / clean water practices	Continued NGO support to further embed practices would likely boost sustainability		
Grow nutritious crops and fish				
Colombia potatoes				
Multiplication of seed of new varieties and dissemination	Private company already selling mini-tubers to commercial growers Some seed grower groups need to keep costs down to get attractive returns	Some technical assistance to groups of small-scale seed growers would help, but not so clear from where	Seed grower groups depend on group activities: has seemingly worked so far	Potential for public procurement of potatoes
Food security schools	Small, but valuable gains to participants in vegetable gardens.	Provincial government will expand the schools into 19 municipalities of Nariño	Community networks help attendance and activities	

	Private gain	Public services	Collective action	Policy
Micro-nutrient sprinkles		Ministry of health programme: will be continued and replicated if found effective		
Ethiopia pulses				
Improved pulse production leads to soil fertility, better nutrition, higher incomes and increased pulse seed availability	Farmers achieved private gains from increased production and improved soil fertility: likely to be sustained.	Increased knowledge of pulse production in extension service will continue to improve services provided to farmers. High staff turnover is likely to erode these over time.	Farmers provide support to each other when problems occur in production, including improved market access, increasing ability to sustain private gains from pulse production. Seed producing cooperatives likely to struggle unless timely seed purchase by parastatal is guaranteed.	Increased interest in pulses likely to be sustained through strengthened institutions (National Pulse Platform).
Improved mother and child nutrition through preparation of pulse-based recipes and complementary feeds for children	Mothers see improvements in children's health: can be expected to sustain changes made.	Health and nutrition services improved through staff training, but likely to be eroded by high staff turnover.	Mothers groups see benefits of nutrition training and can be expected to continue to share their knowledge.	
Ghana ICT extension				
Harnessing interactive digital platforms with mobile-equipped extension agents	Farmers reached by the technologically enabled extension services raise average yields by 15.7%	Technologically, privately owned extension services could be used to complement government extension		

will result in a privately-funded agricultural extension service to complement the government one	Potential third-party providers of the radio and SmartEx services are unconvinced of its financial sustainability without a large cash injection	efforts, but not without significant up-front (public or donor) investment which has as yet been unforthcoming.		
Nepal terrace farming				
Tools, equipment and seeds	Clear gains to users, plus opportunities for agro-dealers and supplier companies	Public information to spread messages: picture books promising		
Agronomic innovations: intercropping, planting on terrace edges, walls	Farmers have incentives, so long as they learn of techniques and how best to apply them	As above, plus promotion through actions of local and national governments, other NGOs		
West Africa vegetables				
Growing more indigenous veg	Good profits to growers, especially adopters of micro-dosing and irrigation. Health benefits understood	Support from state governments and in state-run institutions (schools, prisons) can help.	In certain areas, community understanding that women can use certain land previously male-only.	
Producers of IV-containing foodstuffs	Good profits to small enterprises successfully marketing these as health foods	More support may be needed by NGOs to develop wider demand		
Kenya farm shop				
Franchise shops and farmers using their goods / services	Clear gains to franchisees and farmers	Continued support necessary to support FarmShop parent company until break-even. This in turn supports franchises.		

Tanzania legumes				
Farmers adopt new pulse technologies and access output markets, to increase incomes	Private gains depend on access to markets for most farmers: difficulties accessing markets mean farmers may stop producing legumes. Private gains to female farmers has, more often, taken the form of increased household pulse consumption and so are likely to be sustained.	Resources needed to sustain information services for farmers: unclear whether these will be available after project end.		
Strengthen small-scale farmers' access to input and output markets	Agrodealers benefit from sale of inputs for pulse production: can expect most services to be continued. In some areas agrodealers are concerned about lack of demand and may not continue to provide services.	Resources needed to sustain information services for farmers: unclear whether these will be available after project end.		Improved seed regulations have improved quality of inputs for farmers: likely to be sustained if enforced by government.
Process and fortify foods				
India double-fortified salt				
Making DFS available	Private salt companies involved in the project and others highly likely to see eventual gains.	Access for low-income people now via inclusion in PDS shops. May require lobbying to maintain inclusion in event of change of state-level government.		Potential to make fortification mandatory

Consumption of DFS	Consumers aware of benefits for selves/ family	Government / NGO information dissemination on benefits should boost uptake	Community / social networks may aid marketing, information dissemination.	
India small millets				
Manufacturing and selling dehullers [Continual innovation underway to develop better machines]	Sufficient profits have already allowed companies to scale up and market significantly more dehullers	State has already and may in future purchase some dehullers for public programmes		
Producing small-millet processed foods	For most micro, small, and medium enterprises, sufficient profit and prospects for growth	State support to include millet in processed products, e.g. in school feeding programmes		
Low-income consumer access	Consumers aware of benefits for selves/ family likely to purchase	State support to include in PDS a possibility. NGO support to include via e.g. DHAN's women's federations	Community / social networks, drives e.g. walkathons to promote millet	
Tanzania fortified sunflower oil				
Unrefined, fortified sunflower oil is produced by SMEs and marketed	Clear private gains to SMEs, especially if government enforces fortification laws. In absence of enforcement, SMEs will still profit and continue to produce fortified oil, but likely to sell to easier-to-reach, urban markets.	Government committed to fortification as a means of addressing micronutrient deficiencies: likely to continue.		Commitment to fortification likely to continue given benefits. Unlikely that fortification will be enforced for SMEs.

Increased consumption of vitamin A through unrefined, fortified sunflower oil	Consumers report health improvements and demand is likely to continue.	Without support to SMEs and supply chain, supply will become erratic.		Government committed to fortification messaging: demand likely to continue
East Africa fermented food				
Making probiotic sachets available	Some of the sachets may be sold for commercial yoghurt production, generating profit.	At the moment depends on an NGO (Yoba For Life) shipping sachets in to the region.		
Small-scale producers of probiotic yoghurts and other probiotic foods	Making and selling the yoghurt is proving profitable.	Ongoing support from NGOs to support the small producers, to purchase product (e.g. orphanages) will help	Community / social networks may aid marketing.	
Vietnam therapeutic foods				
Local production of inputs for and processed therapeutic/ complementary foods	Farmers contracted to supply the production operations need to see sufficient income gains; likewise, the small-scale processing unit.	Government / NGOs can purchase therapeutic/ complementary foods from this source rather than importing		
Consumption of foods		Nutrition counselling sessions held (and ongoing) boost consumer knowledge and demand. Public services tracking infant weight/health Parents should see visible benefits in child health and continue use as necessary.		

Avoiding loss and spoilage				
Nanotech for fruits				
Production of hexanal-based technologies More products being developed that also show promising commercial viability	Local company in Tamil Nadu produces hexanal-based sprays and biowax technologies commercially. Indications for other technologies are promising. Local production capacity has been built to a high level and is sustainable.			Regulation — patenting, approval, licensing for commercialisation — have been addressed in India & Canada, being addressed in other countries.
Farmers, growers' associations and fruit packers use hexanal-based technologies	Substantial gains to motivate farmers, packers to use sprays and stickers			
Novel livestock vaccines				
Development of heat-stable vaccine for several small animal diseases	Willingness to pay studies: high likelihood of producing a commercially viable and sustainable product	Vaccination likely to be rolled out as a public service		Vaccines need approval
CBPP Vaccine				
Sub-unit vaccine ready for production in Kenya	Unclear as yet (results of field trials not yet reported) but results of willingness to pay trials are promising	Vaccination likely to be rolled out as a public service		Vaccines need approval. Full field trials have been delayed. Approval likely

Partnerships for scale-up and delivery in Kenya & elsewhere New generation of leaders in Kenya & Canada on CBPP & reverse vaccinology	Partnerships between researchers and vaccine producers in Kenya & South Africa. Presumed highly positive gains to public sector vaccine producers KEVEVAPI & KALRO from strengthened research & vaccine production capacity	Partnerships between public and private sector research organisations National and regional partnerships necessary to roll out the strategy are being built by the project		
Strategy for progressive control of CBPP in Kenya & elsewhere	If vaccine can be produced at scale, potential for substantial gains to livestock farmers across continent.	Two of the diseases are notifiable (potential for outbreaks) so this is likely to fit well into public veterinary service provision of vaccines. Actual strategy has yet to be formulated but is the responsibility of others, not simply CIFSRF project		CIFSRF project making a significant effort to improve the collective action required to license the vaccines regionally
Côte d'Ivoire coconut disease				
Disease control strategy	Private gains expected for all coconut farmers trained in disease control techniques: likely to be sustained.	Sustainability of increased capacity in Ivorian research institutions depends on staff turnover.		
Teaching farmers to control disease on their farms and alternative income sources.	Private gains expected for coconut farmers and ability to earn income from alternative sources if necessary: likely to be sustained.	Sustainability of increased capacity in extension service depends on staff turnover and government resources.	Farmer groups set up to provide alternative income to those affected by the disease expected to increase farmer incomes: likely to continue.	

Appendix D Scoring the CIFSRF Phase 2 portfolio by technical ambition and demands

	Degree of innovation	Breadth of innovation	Social change	Institutional change	Degree x Breadth	Social x institutional	Technical ambition	Social and institutional change required
Colombia potatoes	2	4	3	2	8	6	Moderate. Advanced technology in Phase 1, technology extension in Phase II	Seed growers need to learn exacting skills: for other participants modest changes Much collaboration with government and civil society in Nariño; but requires few institutional changes
Cambodia homestead food	2	4	2	2	8	4	Moderate: most of production techniques, BCC well known	Minor demands on farmer skills; most activities are those that governments and others try to do in any case
Ethiopia pulses	2	3	1	2	6	2	Modest. Better seeds, better cultivation of known crop; nutrition messages well-known	Access to technical advice, supply of quality seeds and inputs main challenges
West Africa vegetables	2	4	2	3	8	6	Moderate. Production techniques well known	Moderate: much engagement with different groups of producers, support agencies, government, etc.
Bolivia Amazon fish	1	3	2	4	3	8	Low. Fish species well known, no change to capture techniques, modest changes to fish farms	Major challenges for capture fisheries: collective management of resource Regulations on fisheries, fish standards Improved access to inputs, finance Famer adoption: increments to farmer skills
Nepal terrace farming	4	5	2	1	20	2	Various: from very simple techniques to advanced technology	Few institutional changes required: coordination with private firm
Kenya farm shop	1	2	2	4	2	8	Low. Retailing and franchising well known	Franchisees have to develop capacity in technical expertise, business skills. Links needed to extension, micro-finance agencies Social change: farmer adoption
Ghana ICT extension	2	2	2	3	4	6	Low. Radio extension quite well known	Key institutional issue is business model: who pays for programming? Apparently still to be resolved. Farmer adoption: increments to farmer skills
Tanzania legumes	2	3	1	2	6	2	Low. Modest changes to cultivation of known crops	Main challenge seen as getting inputs to farmers

India small millets	3	4	3	3	12	9	Technology relatively simple, but multiple technologies involved, raising the challenge	Manufacturers and processors need to increase skills Multiple agencies involved, with demand to coordinate actions
Vietnam therapeutic foods	3	2	2	2	6	4	Moderate: technology straightforward, implementation with small-scale producers more challenging	Processors need to learn new skills, mothers use of therapeutic foods Links to health ministry, UNICEF, etc.
Tanzania fortified sunflower oil	4	1	1	4	4	4	Quite high, one specific technique	Processors need new skills Policy for fortification central to endeavour
East Africa fermented food	3	1	3	3	3	9	Medium. Technology is relatively simple, although novel	Raise technical and business skills of partner processors. Regulation needed
India double-fortified salt	4	1	1	3	4	3	Quite high: technical challenge of making fortification reliable, effective, economic	Critical points: adoption by PDS; compliance by salt processors
Côte d'Ivoire coconut disease	4	2	2	2	8	4	High. Finding causes and responses to disease	Farmer adoption: increments to farmer skills Once solutions are proven, extension to farmers
Nanotech for fruits	5	1	3	2	5	6	High. Novel technology with great potential.	Technology needs to pass food safety tests, be approved. Extension to farmers through growers' associations.
CBPP vaccine	5	1	2	2	5	4		Minor changes for livestock keepers
Novel livestock vaccines	5	1	2	3	5	6	High. Involves producing stable and effective vaccines for CBPP and five other diseases	Gaining regulatory approval a challenge, but does not require new agencies or institutions
High: Count if 4 or 5	7	5	0	3				
Low: Count if 1 or 2	8	10	14	9				