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INNOVATIONS FOR TERRACE FARMERS IN NEPAL AND TESTING OF PRIVATE SECTOR SCALING UP USING SUSTAINABLE AGRICULTURE KITS AND STALL-BASED FRANCHISES: FINAL REPORT

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Innovations for Terrace Farmers in Nepal and Testing of Private Sector Scaling Up Using Sustainable Agriculture Kits and Stall-Based Franchises: Final Report

IDRC Project Number: 107791

Research Organizations Involved in the study
Local Initiatives for Biodiversity, Research and Development (LI-BIRD)
Anamolbiu Private Limited (Anamolbiu)
University of Guelph (UofG)

Location of Study:
Majhthana VDC, Kaski district, Nepal
Jogimara VDC, Dhading district, Nepal

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Executive Summary (2 page max):

Globally, hundreds of millions of people who belong to hillside subsistence farms, struggle with agronomic challenges such as lack of land area for cultivation, erosion and loss of soil fertility, low yield, poor access to agricultural inputs and services, lack of mechanization, illiteracy and female hardship including having to constantly walk up and down terraced hillsides, carrying objects. In Nepal, out of 75 districts, 60 are food insecure and most of these are on hillsides with ~13 million inhabitants. Farmers in these regions earn $1-2 USD per day and do not have access to appropriate agronomic practices or tools although they have traditional ecological knowledge. The development projects implemented by governments and NGOs are not reaching the millions located in remote villages. Adding to the problem is that many interventions are not based on farmer needs; they are often expensive, not purchasable by women, environmentally unsustainable and require female labour (e.g., mulching), and hence are not adopted or scaled up post-project. Further to these challenges is that every farm household has individual needs which requires exposure to a menu of options with the hope that at least one technology will be adopted. Fortunately there are commercial technologies available locally and/or abroad (e.g. Canada, India, China) which are affordable.

The SAKNepal project (Twitter: @sak_Nepal; website: www.SAKNepal.org; mini-documentary film at: https://www.youtube.com/watch?v=HTt0jvG_Yws) was intended to test a model to scale up a regional kit of seed packages, tools and agronomic innovations to reduce female drudgery, help increase crop production/income, and/or enhance environmental sustainability for 25,000+ hillside terrace farm households in Nepal (100,000+ people). As of Jan 2018, we have reached 60,288 households (271,296 people directly or indirectly), especially women farmers. Some technologies are based on farmer surveys from previous CIFSRF research. They are low cost and combined into a commercial menu of options known as a sustainable agriculture kit (SAKs) from which households can purchase/adopt individual items. Forty six products/practices have been pre-tested and improved by an NGO (LI-BIRD) using participatory approaches with test farmers prior to commercial scaling up. Consumer farmers are now purchasing individual technologies from the menu. A graphical flyer can accompany each SAK product to instruct consumer farmers in remote areas, especially illiterate (women) farmers, on how to use the products. The flyers, which when compiled with ~100 additional best practices, comprise the SAK extension picture book and smaller booklets. The project has tested the efficacy of an NGO spin-off company (Anamolbiu) to sell the SAK products, and using pre-existing commercial distribution networks to reach remote villages (peri-urban snackfood and farm machinery dealers, agro dealers, co-ops). At the end of the pipeline, the project has used cell phones to conduct feedback surveys with consumer farmers, using contact information collected from vendors, in order to measure market needs and product impacts, especially on female drudgery, and improve the products, thus increasing long-term adoption rates. Though the project has now terminated, a unique feature is that sales are continuing, and a component of the project (SAK tools and seeds) is now self-sustaining. Different subsets of SAK products/methodologies are transferrable to the world's 400 million subsistence farmer households, especially to improve the livelihoods of women and girls. The major outputs during this reporting period are:

On-farm testing and improvement of 46 SAK products and practices:

- We completed on-farm testing of 25 innovative agronomic practices and 21 tools/products (Annex 3) using participatory methods to generate the regional SAK menu. Based on field trial recommendations and also participatory ranking exercises, 10 products and 11 practices were selected as champion SAKs for scaling up, focusing on female farmers.

- On-farm testing on terraces demonstrated income impacts of up to hundreds of dollars per household from individual agronomic innovations (e.g. intercropping), and tens of hours of female drudgery reduction from individual tools (e.g. CAD $2 corn sheller).
- A conceptual breakthrough was the demonstration that the underutilized vertical surface area (terrace risers) can be used to grow crops (at the terrace edge or base, e.g. planting yams in sacks at the base). Such intensifying agronomic practices are transferable worldwide.

Production and testing of the knowledge extension model:

- The world's most comprehensive picture books of best practices/ products for subsistence farmers have been created, tested with female farmers, and published to assist illiterate women farmers in particular (150 lessons, totaling ~190 pages).
  - Five book versions have been created (South Asia, Sub-Saharan Africa/Caribbean, East Asia, Latin America, North Africa/Middle East) for download at no cost (http://www.sakbooks.com), encompassing a total of 900 pages that may be mixed/matched to create customized booklets.
  - A parallel written book (*Encyclopedia of Subsistence Farming Solutions*) that describes and critically evaluates >100 SAK products/practices (currently ~350 pages) is now online (draft, at www.SAKBooks.com) to help people in other nations to understand/adopt SAKs.
- To disseminate the project results globally, the project is in the process of generating ~55 publication outputs (27 published, 3 submitted and >20 in preparation) including peer-reviewed journal manuscripts or book chapters (39), books/booklets (4), MSc/PhD theses (5), government reports (3) and impact stories of change (4).

Testing and implementation of the scaling up model:

- An innovative pipeline for private-sector scaling up has been successfully established which has impacted up to 271,295 people directly or indirectly:
- 25,955 households, representing ~116,797 people, have purchased at least one SAK product, though the innovative snackfood and machine shop channels represent only a small but promising fraction of this success.
- 30,490 additional households (~137,205 people) benefited indirectly, as local NGOs and the government purchased SAK products from Anamolbiu Ltd. for farmers
- 3843 households (~17,293 people) have adopted at least one SAK agronomic *practice* but there are likely more that are difficult to track (secondary users from knowledge diffusion).
- 1100 remote consumer farmers, who purchased SAK products, participated in cell phone surveys, using the contact information collected by vendors when they purchased SAK products. We consider this approach as a novel impact-assessment method which can be implemented in other remote regions of the world.
- Nearly 500 Canadian Youth Agri-Food Trade Ambassadors have identified, evaluated and promoted ~500 unique bi-lateral trade opportunities between Canada and Nepal.
- Led by the above Canadian student initiative, the project successfully organized a national level workshop on 'Agro-based trade between Nepal and Canada' on Jan 8, 2018 to catalyze bilateral trade between our two nations. In total, 44 participants, including high level dignitaries, attended the event, including representatives of the trade sector, academia, the Government of Nepal and NGOs.

Notable Project and Trainee Recognition

- PhD students Kamal Khadka and Rachana Devkota were both awarded IDRC Doctoral Scholarships. Rachana was awarded *The David and Ruth Hopper and Ramesh and Pilar Bhatia Canada Fund Scholarship* given to the top female nationally among all IDRC doctoral scholarship winners.
- University of Guelph Research Associate Tejendra Chapagain and post-doc Malinda Thilkarathna were both short-listed (top-3) for a faculty position in agronomy at Guelph.
- Manish Raizada was invited to give prestigious lectureships at the John Innes Centre UK and at the University of California at Berkeley including on the SAKNepal project.

1. The research problem (1 page max.):

Millions of smallholder terrace farmers around the world, especially female farmers, face similar challenges: limited land surface area for cultivation, soil fertility degradation, female drudgery (e.g. for land preparation, seed sowing, weeding, grain threshing), labour shortages due to male out-migration (Annexes 1.1, 1.43-1.47) and decreasing crop yields in part due to decreasing available manure and limited irrigation facilities. Farmers living in remote regions especially in the hills and mountains have poor access to government extension services and private sector products. Many development projects reach only hundreds of farmers, at great cost, in regions inhabited by millions of needy households. At the same time many of the interventions are expensive, complex and incompatible to the local context, environmentally unsustainable or require significant labour and hence are not adopted or scaled up after the project. For example, introduction of large machinery such as the power tiller machine (expensive, incompatible) or practices such as the system of rice intensification (SRI) and zero/no tillage cultivation of wheat (complex and requires more labour for weed and water management) have been difficult to scale up in the mid-hills of Nepal. There are some commercial technologies available locally or in distant markets (outside the country), which are suitable for terrace farming, but these products are often inaccessible to poor farmers, because NGOs and governments often attempt to create their own distribution networks rather than using effective, pre-existing networks (e.g. snackfood). Interventions also fail because of a lack of understanding of the entire farm and household system and the actual need. Scaling up knowledge sharing of best practices, such as through books, can also be limited by low female literacy in rural areas.

Similar to elsewhere in the world, in Nepal, terrace farm households face a number of agronomic challenges (Annexes 1.1, 1.17-1.19, 1.30, 1.43-1.47). These include: lack of quality land area for agriculture, erosion and loss of soil fertility, poor access to agricultural inputs and services, lack of mechanization, labour shortages, poverty, and illiteracy resulting in the lower yield and agricultural productivity compared to other South Asian countries. Food imports have been increasing significantly for over the last 10 years (6 times higher in 2016/17 compared to 2006/07) with a total import value of over 173 billion Nepalese rupees in 2016/17, while the export value was just 29 billion rupees. Yet there are opportunities for innovation. Though terrace farming can cause significant female hardship, many excellent ideas and simple tools/machines are available that hold potential (Annexes 1.1, 1.19-1.20, 1.36, 1.39). Though there is limited land area for farming, an opportunity is the 20-50% of underutilized surface area on terraces that is vertical (the terrace walls or risers). Such vertical slopes as well and terrace edges (which are generally wasted) could be utilized by cultivating climbing/trailing legumes and other suitable crops.

The SAKNepal project has been an attempt to address the challenges in hillside agriculture by intensifying terrace farming as a research model. It introduced, tested and is continuing to scale up commercial technologies in Nepal that are available elsewhere around the world. The project tested Sustainable Agriculture Kits (SAKs), consisting of a menu of free or low cost purchasable interventions, that are chosen by farmers through SAK surveys and project meetings, focusing on increased productivity, income generation, reducing female drudgery, promoting climate change resiliency, reducing post-harvest waste and promoting sustainability (Annex 1.36). The project built upon a previous CIFSRF project which was focused entirely on finger millet, and discoveries and contributions (Annexes 1.5-1.12) continue to be made by our team about this orphan crop, which we hope will feed into future SAK products and recommendations. One of these discoveries was published (in 2016) in the prestigious journal *Nature Microbiology* (Annex 1.5) and featured on CBC Radio *Quirks and Quarks*, with an audience of 800,000.

In terms of the current overall progress of the project, the main scientific innovations of this project included a new method to detect and visualize symbiotic nitrogen fixation (SNF) and novel agronomic innovations pertaining to growing crops vertically on terrace walls. With respect to development, the main innovations of this project pertained to the SAK scaling up model which brought a private sector approach to development analogous to initial consumer surveying of needs (SAK survey), beta testing of products (test farmers, on-farm), use of innovative distribution channels to reach the target consumer (e.g. snackfood dealers and others), including pictorial instructions on use of the products (SAK picture lessons), followed by a consumer feedback survey (via cell phones).

2. Progress towards milestones (5 pages max.):

The milestones (36 and 42-month) were revised (Annex 2) after obtaining a 12-month no-cost extension in October 2016. All the agronomic trials were successfully accomplished in 678 farmers' fields at Kaski and Dhading districts. Also, testing of different products and private sector scaling up were accelerated (results in Section 4):

3.1 Working with test farmers, complete all field activities and demonstrate impact of SAK products/practices that meet Objectives 1-4, including: (1) intensify terrace agriculture (e.g. measure terrace yields, profit, crop diversification); (2) reduce female drudgery (e.g. quantify female labour in hours, physical strain); (3) promote environmental sustainability and climate change resiliency (e.g. measure manure quality, legume yield/usage, post harvest losses, etc); (4) promote farmer self-reliance (i.e. evaluate farmer seed production strategy) (LI-BIRD, UG);

For (1-3), we exceeded the original project objective of testing 20 SAK innovations: instead 46 innovations (25 agronomic practices and 21 tools/products) were tested through initial split-plot, on-farm field trials in Nepal; the trials and their outcomes are documented (Annex 3).

In terms of SAK agronomic practices, those tested and selected for scaling up included: 1) growing yam (in sacks), pumpkin and chayote on terrace walls; 2) growing ricebean, cowpea and horsegram in terrace edges; 3) ginger + maize-soybean intercropping; 4) maize + cowpea intercropping; 5) millet + soybean intercropping; 6) plastic greenhouses combined with drip irrigation and plastic collection ponds; and 7) cattle shed improvement for improved farm yard manure (FYM) preparation. Similarly, SAK products (i.e. tools and materials) that were selected for marketing through Anamolbiu's distribution network included: 1) the hand held corn sheller,

2) vegetable composite seed kits, 3) field rake, 4) garden gloves 5) legume seed kits, and 6) low oxygen grain storage bags.

For farmer seed production (hybrid maize), we initiated the project and drafted a comprehensive journal paper to catalyze such efforts, but we are behind schedule in scaling up in part because we are awaiting new inbred parental lines from NARC. Once received, we are track to produce 3000 kg of hybrid seed which would be sold through Anamolbiu in the coming years.

2. Working with test farmers, consumer farmers and other extension stakeholders, measure effectiveness of the SAK picture book lessons (Objective 5) using focused surveys, with a focus on gender impacts.

The SAK picture book (~190 pages) of 150 low-cost/low-labour best practices was developed as a novel extension model targeting rural illiterate women farmers. The book was revised following participatory editing with female farmers and then published (Annexes 1.27.1-1.27.6). Altogether, 5 versions of the picture book were published (South Asia/Nepali, Sub Saharan Africa/Caribbean and East Asia, Latin America, North Africa/Middle East). The entire book(s) as well as the individual lessons, to create customized booklets, are free to download at www.sakbooks.com) and we request IDRC's help to dessiminate their availability. To measure effectiveness of the picture book, a separate survey was conducted at two project sites. The quantitative data show that women found most lessons to be useful and simple to understand across socio-economic strata; a final survey is ongoing, distant to the project sites, funded by an IDRC Doctoral Award (to Rachana Devkota). The findings will be published in 2018.

3. To measure the progress in developing a commercially viable scaling up model (Objective 6), complete feedback surveys by cell phone with a combined project total of 3000 consumer farmers as SAK products and practices focusing on their impact on key project indicators such as improved farmer income and reduced female drudgery (3rd party Anamolbiu/LI-BIRD/3rd party CMU), and continue to measure sales, geographic reach, number and type of distributors (3rd party Anamolbiu). Complete final analytical report.

During the reporting period, we continued testing commercially viable scaling up models on a few selected SAKs which appeared to be productive/effective and which showed the greatest potential for adoption and commercial viability. Scaling up included both products and practices.

This project adopted four key approaches to scale up SAKs practices: 1) orient leader farmers around the test sites about SAKs and assist these farmers for field demonstrations; 2) disseminate SAK practices in combination with associated products; 3) expand the technologies through LI-BIRD and NGO partners programmes, and 4) integrate SAKs into the government's local development plan to leverage resources. As of January, 2018, 3061 households (i.e., non-test HHs) have adopted different SAK practices (Please refer to Section 3, Table 5).

Comparative testing of SAK marketing channels (i.e., peri-urban snackfood dealers, agricultural cooperatives, agro-veterinary dealers, and utensil/hardware suppliers) was continued in more than 10 districts. Specifically, the handheld corn sheller, vegetable composite seed kits, farm rake, legume seed kits and super grain bags were supplied to vendors for sale. As of January, 2018, a total of 25,955 HHs (impacting up to 116,797 people) purchased at least one SAK product. Additionally, 30,490 households (impacting up to 137,205 people) benefited indirectly as NGOs and governments purchased SAK items from Anamolbiu Ltd. for farmers (Please refer to section 3, Table 6).

The cell phone consumer questionnaire was designed for the selected products and initially tested with 100 consumer farmers who purchased SAK products as a pilot project. The, a revised questionnaire for five SAK products was used to collect consumer feedback. Based on survey metrics, we calculated that total required sample size was 1228 if considering four promising products (e.g., hand held corn sheller, vegetable composite kits, field rake and low oxygen grain storage bags). As of Jan 2018, 1106 responses have been collected. Anamolbiu will continue to conduct surveys in the future as well. From the available data, the impact of the SAK scaling up method has been evaluated (Section 4). For SAK practices, a consumer feedback survey of 297 households has been completed. Basic findings are presented in Section 4. Comprehensive analysis of whole feedback surveys is ongoing for publication in 2018.

4. End of Project conference/workshop to disseminate project results (including report on all objectives, SAK sales and consumer surveys, and include key recommendations for future scaling up in Nepal and other nations), involving project partners, stakeholders and policy makers (All).

A final project meeting was organized on Jan 5-6, 2018 in Pokhara, Nepal (Annex 4). Delegates from the Department of Agriculture, National Agriculture Research Council, Prime Minister's Agriculture Modernization Project (i.e., Government of Nepal's largest project in agriculture), newly elected local government representatives as well as the SAKNepal project team participated in the event. The representatives visited a project site in Kaski to observe/review project achievements which was followed by an in-house meeting/workshop to discuss and disseminate project results. Details of the meeting along with remarks from the invited delegates are captured in the meeting minutes (Annex 5).

In addition, a workshop, entitled 'Agro-based trade between Nepal and Canada', was organized in Kathmandu on January 8, 2018. This workshop was organized in partnership with the Agro Enterprise Centre (AEC) which works under the umbrella of the Federation of Nepalese Chambers of Commerce and Industries (FNCCI). A total of 44 participants representing agriculture and agri-food companies in Nepal as well as government agencies (Ministry of Commerce, Ministry of Agriculture), FNCCI and NGOs actively participated in the workshop. Discussed at the workshop were: current international trade scenarios for Nepal and export potential to Canada, current status of Nepal-Canada trade, prevailing issues/challenges and opportunities for bilateral trade in the agri-food sector between Canada and Nepal (Annexes 1.49.1-1.49.7) and opportunities identified by University of Guelph students (see www.SAKNepal.org). A report on the details of the trade workshop is attached (Annex 1.50).

5. At least 5 publishable manuscripts developed and/or submitted for peer-reviewed journals. Present project strategies and results at a minimum of 2 scientific, 2 international development and 2 business conferences and workshops (All).

We had 8 outputs (3 submitted and 5 published) during the reporting period. Published were:

1. *Agronomic challenges and opportunities for smallholder terrace agriculture in developing countries* by Tejendra Chapagain and MN Raizada in *Frontiers in Plant Science* 8: 331 (March, 2017). Annex 1.1.

2. *Mitigating dry season food insecurity in the subtropics by prospecting drought-tolerant, nitrogen-fixing weeds*, F.Small, MN Raizada in *Agric & Food Security* 6:23(Mar, 2017). Annex 1.2.
3. *A Biosensor-Based Leaf Punch Assay for Glutamine Correlates to Symbiotic Nitrogen Fixation Measurements in Legumes to Permit Rapid Screening of Rhizobia Inoculants under Controlled Conditions (relevance: proof of concept GlnLux paper)* by Malinda Thilakarathna, Nick Moroz and MN Raizada in *Frontiers in Plant Science* 8: 1714 (October, 2017). Annex 1.4.
4. *Impacts of natural disasters on smallholder farmers: gaps and recommendations* by Tejendra Chapagain, MN Raizada in Agriculture & Food Security 6:39 (May, 2017) Annex 1.30.
5. *Challenges and Solutions of Subsistence Farmers* by MN Raizada, for the popular U.S. undergraduate textbook, <u>Plants, Genes and Agriculture</u> (Oct 2017). Annex 1.21.

The 3 journal manuscripts that were submitted were: a climbing legumes review (Annex 1.22), GlnLux technology visualization (Annex 1.23), and mechanization policy in Nepal (Annex 1.34). We are also nearing submission of the major agronomic field trials in Nepal (Annexes 1.24-1.26). *The latter manuscript and the current ones being drafted better integrate the Nepali team.* Indeed, ~20 additional manuscripts are in the pipeline for journal submission in 2018, many project-level. Similarly, papers were presented at two business conferences and workshops in Kathmandu (Agro-based trade between Nepal and Canada, Annexes 1.49.1-1.49.7) and Cape Town, South Africa (Annex 1.48). Components of the project were presented at 5 lectures by M. Raizada (University of California at Berkeley, Oct 25, 2017; IDRC-Ottawa, Sept 14, 2017; 29th Fungal Genetics Conference in Asilomar, California, March 17, 2017; and John Innes Centre, UK (Mar 1 and 2, 2018) (Annexes 1.51-1.55). Papers/posters were presented at 5 conferences.

6. End of project evaluation and impact assessment documenting progress towards key objectives and research for development outcomes (All), for both test farmers (based on detailed measurements) and farmers-as-consumers who purchased/attempted a SAK product/practice (based on cell phone surveys of 3000 consumers and sales data):

Results related to agronomic evaluations/test farmers have been sumarized and developed as manuscripts (e.g., Annexes 1.24-1.26) for submission in Spring 2018. Similarly, individual SAK product evaluation methodologies and findings with test farmers have been compiled and are being considered as as a separate manuscript (led by R. Pudasaini). Impact assessment associated with consumer farmers (scaling up phase) are being measured in terms of the extensive cell phone surveys completed (Section 4); these findings will be published in late 2018, and a separate manuscript focusing on the corn sheller is being drafted. Furthermore, there are 3 stories documented, published and disseminated to highlight the three major findings of this project in the form of stories of change (Annex 1.20, Annexes 1.32-1.33).

3. <u>Synthesis of research results to date (10 pages max.):</u>

We have published a comprehensive review/perspectives blueprint paper on the agronomic challenges and potential (SAK) solutions for terrace farmers (Annex 1.1) which is complemented by data from agronomic field trials. We have also created a blueprint recommendation for how the international community can help subsistence farmers after a natural disaster (such as the earthquake in Nepal) by distributing emergency SAKs (Annex 1.30; DFATD report at Annex

1.31). During the past 12 months (Feb 2017 - Jan 2018), we continued testing ~46 SAK interventions through on-farm trials on Nepalese terraces (see Annex 3 for overview/summary) and scaled up the successful innovations via different channels. The relevant project objectives and the results of testing and scaling up of the most successful innovations along with the research on testing scaling up models and/or approaches are summarized as follows:

3.1 On-farm testing and improvement of 46 SAK products and practices

Tools and machinery to reduce female drudgery in agriculture:

We tested 21 SAK products; 16 were intended to help women to reduce agricultural drudgery (please refer to Annex 3 for the list of tested SAK products and Table 1 for test findings for selected products). The products that reduced female drudgery in terrace farming included tools to remove corn kernels from cobs (e.g., corn shellers), tools to replace livestock and personnel required for behind-the-plough sowing of seed (e.g., jab planters), as well as products to reduce discomfort (e.g., gloves and knee pads), weeding time (e.g., fork weeders), clearing debris at planting and assisting farmers to spread manure rather than by hand (e.g., farm rakes), reduce labour during land preparation (e.g., gas mini tillers) and drudgery in threshing (e.g., millet grain threshers). Participatory on-farm training and testing followed by focus group discussions or surveys were employed. In total, 488 test farmers (86% female) tested SAK tools.

Table 1. Test findings for some products intended to reduce female drudgery.

SN	Selected Products	Test findings (comparison with traditional practice)
1	Handheld corn sheller	Reduced time requirement by 70% compared to hand shelling (36 hours of labour per HH per season).
2	Farm rakes	~50% time saving in weeding and cleaning the cattle shed and crop fields, reduced minimum 1 hour in a week. i.e., 48 hours per HH in a year.
3	Super grain bag (SGB)	100% control of insect attack, saved time (previously took >12 hours per HH to clean seeds stored in ordinary bags).
4	Composite vegetable seeds	Increased vegetable diversity; increased vegetable production and consumption by 26%.
5	Fork weeder	Reduced drudgery significantly as well time required for weeding by at least 25% (>90% respondents n = 40).
6	Electric millet thresher	75% time saving in millet threshing and significant reduction in physical strain; reduced 36 hours in a year/HH
7	Mini-tiller	Reduced 64 hours per year per HH for field preparation, significant reduction in physical strain.
8	Fruit picker	Increased safety and reduced drudgery (>90% respondents, n = 140)
9	Hand gloves	Increased safety and reduced physical strain (>90% respondents, n = 140).
10	Silpaulin plastic	Combined with drip irrigation and plastic house; contributed to increase income.
11	Legume seed kit	Increased yield (>25%)

Following testing, farmers rated them as good (score of 1), better (score of 3) or excellent (score of 9) across six criteria: i) relative advantage, ii) compatible, iii) simple, iv) amenable to trial by farmers, v) visible effectiveness, and vi) affordable, based on Rogers[1]and Tidd's[2] work (Table 2). Seven drudgery reducing tools were highly rated by the farmers including the hand held corn sheller, electric corn sheller, farm rake, fork weeder, millet thresher, gloves and fruit picker (Table 2). Farmers gave high ratings to tools that reduced drudgery, had multiple uses and were affordable. The handheld corn sheller at NPR 200 (CAD $2.50) per piece was the biggest success. Farmers liked its portability, allowing them to do corn shelling anywhere, simplicity in operation and low cost. On average, the corn sheller saved each farmer 36 hours of labour per season, and test/consumer surveys showed increased male participation in this traditionally female activity.

Table 2. Farmers' ratings on technologies against six scaling up evaluation criteria based on Rogers[1]and Tidd's[2] work.

SN	Product	Farmers' overall responses							Gender	
		Advantage	Observability	Trialability	Simplicity	Compatibility	Affordability	Total	Male	Female
1	Composite Vegetable Kit	9	9	9	8	9	9	53	51	54
2	Silpaulin sheet	9	9	6	7	9	9	49	44	54
3	Electric corn sheller	9	9	7	9	8	5	46	44	48
4	Farm rake	6	6	9	9	8	8	45	45	44
5	Fork weeder	6	8	8	9	8	8	45	47	42
6	Fruit picker	8	9	9	9	9	8	51	54	48
7	Gloves	8	8	9	9	9	9	51	54	48
8	Hand held corn sheller	9	9	9	9	9	9	54	54	54
9	Jab Planter	6	8	3	6	5	2	29	23	35
10	Jab planter (tube type)	2	4	2	6	5	3	21	27	15
11	Maize/pulses grinder	3	9	4	6	8	6	35	37	33
12	Millet thresher	9	9	5	5	9	6	42	39	45
13	Mini tiller	9	9	4	4	4	6	36	29	42
14	Super Grain Bag	9	9	9	9	9	6	51	51	51
15	Table top corn sheller	2	6	3	2	4	2	17	16	18

[1]Rogers, E. 2003. Diffusion of Innovations, 5th Edition. Simon and Schuster.
[2]Tidd, J. 2006. Innovation Models. Imperial College London, Tanaka Business School, Discussion paper

Local perception of what can and cannot be considered as agricultural tools affected the adoption of tools. For instance, the knee pad, brace belt and magnifying glass were seen as athletic gear, medical equipment and a toy, respectively. Farmers did not take these seriously for farming and hence they were not adopted despite appearing functional and affordable to the project team.

Initial drudgery reducing tools/machines considered by Anamolbiu Company for scaling up were the hand held corn sheller, farm rake and gloves. Altogether 21,356 units were sold (Table 3, highlighted rows). The consumer feedback survey showed that the hand held corn sheller was primarily used by female members (81%) of the family (Table 3). Similarly 89% and 95% users of farm rakes and garden gloves were women. *[More about testing is in Annex 1.32, Story of change: Testing and scaling up of sustainable agriculture kits].* These products and their usage were included in the SAK extension picture book (Annex 1.27) to accompany SAK products.

Table 3. Females as primary users of SAK products.

SN	Products	Unit Price (NPR and CAD)	Total sales	Male as primary user	Female as primary user
1	Hand held corn sheller	200 ($2.5)	18574	19%	81%
2	Vegetable kit	100 ($1.2)	25608	8%	92%
3	Farm rake	300 ($3.5)	2256	11%	89%
4	Legume kit	250 ($3)	5185	10%	80%
5	Super grain bag	300 ($3.5)	4155	12%	88%
6	Silpaulin sheet	6000 ($75)	81	40%	60%
7	Gloves	200 ($2.5)	566	5%	95%
8	Drip irrigation set	4000 ($50)	20	40%	60%
Total			**56,445**	**Avg: 18%**	**Avg: 82%**

Farming on terrace walls and edges: reducing female drudgery & enhancing nutrition/income

This is one of the scientific highlights of this project, as our results can be a model for the millions of terrace farmers around the world. Currently, the vertical slopes (terrace walls or risers) are under-utilized worldwide. In the SAKNepal project, we have tested various innovations (Table 4; Annex 1.25). Specifically, we completed testing growing yams (in sacks), chayote, and pumpkin on terrace walls (at the base) as well as rice bean and horsegram on terrace edges.

<u>Test results:</u> The agronomic invention of planting yams in sacks at the base of terrace walls resulted in an average of 7 kg of tubers/per sack with a potential economic return of $5 per sack; it reduced drudgery (digging) associated with harvesting tubers from pits. Similarly, growing chayote squash, which is high in folate for pregnant women, produced up to 350 kg of fruit per plant with a potential net benefit of up to $67 per farmer. Legume crops (e.g. rice bean) planted at terrace edges that trail down on terrace walls yielded 0.43 t/ha of extra high-protein grain per family, potentially worth $436 (Table 4). These crops provided grain legumes as sources of complementary amino acids (protein) as well as micronutrients to local households, and nutrient-rich fodder for livestock. Though the price is highly fluctuating, there is always space for selling these crops in local and regional markets. Therefore, the results have been very successful.

Scaling up: Based on test results and farmers' preferences, the project scaled up yam, pumpkin and legumes (on terrace edges). Altogether 620 HHs tried these three technologies with direct project support (Table 5) of which 397 HHs (64%) have continued these interventions. Additionally, 405 HHs around the test sites (beyond test farmers) have adopted these agronomic interventions. In addition to test farmers, the project has supported an additional 1224 households in neighbouring villages as well as other districts (LI-BIRD's projects) to test/demonstrate these technologies. It is anticipated that these interventions will have a multiplying effect in the future. These lessons were included in the SAK extension picture book (Annex 1.27) which has/is being distributed; which we anticipate will have an impact on a longer time-scale. To catalyze the global terrace farming community, a comprehensive review of candidate climbing legumes for different regions of the world has been submitted (Annex 1.22).

Outcomes: 150 randomly selected farmers from the total adopters of wall crops (yam, pumpkin and legumes) were surveyed to decipher impact. It was found that each household was growing six sacks of yams (average) which produced 34 kg of tubers equivalent to NPR 1700 (CAD $21). Farmers in Dhading preferred pumpkin compared to farmers in Kaski due to a higher commercial value. In Dhading, farmers grew 20 pumpkin plants per household whereas in Kaski they grew 4 plants per household with an average yield of 121 and 24 kg in Dhading and Kaski, respectively. The price of pumpkin ranged from Rs 20-30 per kg. Households who cultivated legumes on terrace edges harvested 7 kg and 10 kg of grain (ricebean in Kaski, and horsegram in Dhading, respectively). These crops fetched NPR 200/kg in the market. Such crops are helping smallholder farmers to obtain a modest amount of hard cash from previously underutilized land.

Table 4. Test findings* for some selected agronomic practices.

SN	Selected Practice	Test findings (comparison with traditional practice)
1	Yams growing in sacks growing up on terrace walls	An average of 6 kg of tuber per sack with an increase of potential income up to $5 per sack.
2	Chayote squash growing up on terrace wall	Produced up to 350 kg of fruit per plant with a potential net benefit of up to $67 per farmer.
3	Pumpkin growing up terrace wall	An average of 52 kg of fruits per plant with an increase of potential income up to $12 per plant.
4	Rice bean on terrace edge	An average of 0.43 t/ha with potential economic return of $436 per ha per season.
5	Horse gram on terrace edge	An average of 0.32 t/ha with potential economic return of $424 per ha per season.
6	Cowpea on terrace edge	An average of 0.29 t/ha with potential economic return of $368 per ha per season.
7	Black gram on terrace edge	An average of 0.25 t/ha with potential economic return of $298 per ha per season.
8	Maize + cowpea intercropping (on flat terrace)	Total land output (t/ha) 26% higher than the maize sole crop with an increase of potential economic return by 64%.
9	Millet + soybean intercropping (on flat terrace)	26% higher total land output than the millet sole crop with a 154% increase in potential income

10	Mustard + pea intercropping (on flat terrace)	30% higher total land output than mustard sole crop with a 12% increase in potential income.
11	Wheat + pea intercropping (on flat terrace)	16% higher total land output than wheat sole crop with a 30% increase in potential income.
12	Ginger + maize-soybean intercropping (on flat terrace)	2% higher total land output compared to when ginger was cultivated alone with an increase of potential economic return by 11%.
13	FYM improvement demonstration	Nitrogen (1.1 *vs* 0.6%), Phosphorus (0.7 *vs* 0.3%), and Potassium (0.8 *vs* 0.4%) between improved and farmers' prepared FYM
14	Drip irrigation and Plastic house	Net income of up to $200 over 5-6 cropping cycles.
15	Hybrid maize seed production	Increased income potential 3 times than the regular maize seed.

*Average value derived from 20 farmers' fields at each site in the Kaski and Dhading districts.

Terrace intensification with legume intercrops: improving yield, income and dietary protein

Subsistence farmers have a carbohydrate rich diet, but an amino acid (protein) deficient diet. We tested nine different intercropping combinations with the main season crops maize, millet, wheat and mustard (Annex 1.24). Four combinations were scaled up as they appeared to be productive and liked by farmers. Intercrop combinations chosen were protein-rich legumes (i.e. maize + cowpea, millet + soybean, mustard + pea and ginger + maize-soybean) that were productive from the 2015 and 2016 field trials. Per site, we collected data from 20 farmers' fields for each combination.

Test results: The agronomic invention of planting ginger + maize in spring/summer (March-July) followed by soybean after the maize harvest in summer/winter (July-Nov) was productive (11% increase in potential income compared to sole ginger) and was preferred by farmers (Table 4, Annex 1.24). The maize + cowpea intercrop showed a 26% average yield increase, and 64% increase in potential income). The millet + soybean system (26% yield gain on average) resulted in a 154% increase in potential income. Finally, the mustard + pea intercrop (average 30% yield gain) resulted in a 12% increase in potential income. These intercrop strategies were selected for scaling up

Scaling up: Initially, 295 farmers tested one of the intercropping strategies with project support of which 255 (86%) are continuing (Table 5). The adoption rate is high due to their compatibility and low investment required. An additional 265 households are replicating these practices through farmer-to-farmer extension. Furthermore, the project has supported 687 farmers outside the test sites as demonstrations. The lessons are included in the SAK picture book (Annex 1.27).

Outcomes: With maize and cowpea intercropping, 32 out of 42 farmers had an average of 10% increase in maize yield. They further harvested ~8 kg of cowpea per household which was mostly used for home consumption. Maize yield was also improved in ginger + maize/soybean intercropping. Farmers who adopted this technology experienced a 7% increase in maize yield.

They further harvested soybean (~5 kg per HH) and ginger (~61 kg per HH). Soybean was mainly consumed by farmers' families but ginger was sold [average of 56 kg ginger sold by each household at an average price of NPR 53 per kg (CAD 0.66)]. Furthermore, 16/26 farmers reported increased millet yield (average 7%) after adopting millet + soybean intercropping. Average soybean yield was 7 kg per HH which was mostly consumed by farmers' families. In the case of mustard and pea, 24/30 farmers experienced increased mustard yield (on average by 9%). They harvested ~5 kg of pea per HH which was used for home consumption. Many neighbours (i.e., non-test farmers) also said that they were going to adopt these practices.

Optimizing legume yield and protein through the use of rhizobia inoculants and micronutrient fertilizers (potential future SAK products) using the GlnLux diagnostic technology:

Indoor trials: This project aimed to optimize the yield and total protein (nitrogen) of legumes since smallholder farmers are typically protein deficient. To assist this goal, the University of Guelph pioneered a novel diagnostic invention that measures the output of symbiotic nitrogen fixation (SNF, the conversion of atmospheric nitrogen gas to ammonia by symbiotic rhizobia bacteria in legume root nodule organs; ammonia is the building block of amino acids/protein). Globally, legume yields/protein suffer from incompatible rhizobia strains in local soils and/or inadequate micronutrient fertilizers required for SNF (we published a review/recommendations on the subject, see Annex 1.3). We optimized the GlnLux technology using diverse Nepalese legumes and showed that the process can employ non-destructive leaf punches and could reduce the current diagnostic cost from $10 to $1 CAD, essential for organizations assisting smallholder farmers (Annex 1.4, Annexes 1.37-1.38). The *GlnLux* leaf punch test is an excellent initial indoor method to screen rhizobia strains and legume genotypes for improved SNF, to reduce the number of candidates prior to field testing (Annex 1.4). The technology was transferred to Nepal, published in late 2017 and has already been formally requested by 6 universities in Europe/U.S. including INRA-Montpellier which assists African farmers. We developed a parallel breakthrough technology allowing us to actually visualize SNF-active root nodules directly (Annex 1.23), to permit global research efforts to uncover and overcome nodules that show suboptimal activity. At Guelph, this new imaging method is leading to scientific discoveries pertaining to the effects of defoliation, nematodes and nitrogen release (for publication in 2018).

Trials to validate applicability of the GlnLux method under field conditions:
Terrace field trials: On-farm trials were conducted to evaluate the effectiveness of adding cost-effective micronutrient fertilizers known to enhance SNF (e.g. molybdenum and boron) as well as rhizobia bacteria (from Canada and locally from Nepal). Specifically, these technologies were tested with respect to improvements in symbiotic nitrogen fixation (SNF) and yield (grain and shoot mass) in Nepalese cowpea, common bean, kidney bean and lentil (Annex 1.26). Eighty trials (10 per site per crop) were established in Kaski and Dhading and a manuscript is being prepared.

The findings (Thilakarathna et al. 2018 manuscript draft) show that the effect of rhizobia inoculants and B/Mo micronutrient treatments were positive for common bean compared to cowpea. Specifically, in common bean, the treatments increased the nodule number (18-163%), nodule dry weight (23-145%), shoot dry weight (6-33%) and shoot total N content (9-74%) at flowering stage that resulted in higher grain yield (20-41%) and grain N content (11-41%) compared to the non-inoculated control plots. For cowpea, rhizobia and/or micronutrient treatments increased nodule number (2-43%), nodule dry weight (4-25%), shoot dry weight (1-10%), shoot total N content (2-17%), grain yield (1-31%) and grain N content (2-11%) compared to the un-inoculated control (Annex 1.26). The data on kidney bean and lentil are being analysed. The site effect had a significant impact on the parameters tested, primarily due to the differences in the rainfall received at each test site.

Replicated trials in Terai: Two additional trials with Kidney bean (var. PDR 14) and lentil (VAR. Sheetal) were established in Nawalparasi district of Nepal to confirm the effects of micronutrients and rhizobia bacteria observed on terrace farms. The terai region is considered as an important legume growing area, and hence these trials can have a significant impact on the use/adoption of rhizobia/micronutrient treatments of seeds.

Field trials in Canada: 50 soybean varieties and 20 common bean varieties were evaluated under field conditions and analyzed using *GlnLux;* a manuscript will be submitted in 2018.

Improved farmyard manure (FYM) prep and scaling up: nutrition, animal health & women

Traditionally, farmers heap FYM uncovered; during rainfall, precious nutrients leach. Furthermore, the nutrient-rich livestock urine is often wasted. Furthermore, in traditional sheds, animals are exposed to urine/feces, resulting in disease. Conditions were dirty for women to collect manure/urine. Improved FYM techniques (shed improvement, FYM prep in a semi-pit under a roof cover and mixing urine with the manure) were evaluated and modestly scaled up.

Scaling up: The project initially helped 72 farmers at two sites to construct improved sheds (Table 5). We supported 50% of the cost (Total cost: NPR 10000/CAD 125). Now, they are using improved methods for FYM prep. Additionally, 48 HHs have self-started the practice. Additionally, the project supported 102 HHs outside the test sites and in other LIBIRD's projects. Several FYM-related lessons were included in the SAK picture book for wider scaling up (Annex 1.27). For wider scale up, LI-BIRD is also encouraging farmers to use 50% subsidy schemes for agricultural tools/infrastructure offered by the Department of Agriculture in Nepal, to improve their cattle shed/FYM. Alternatively, farmers can use their money from the cooperatives that operate savings and credits/finance mechanisms at the local level.

Outcome: Farmers notice less animal disease, women have cleaner day-to-day conditions, and manure quality has improved. 21/22 randomly surveyed farmers reported increased yield of rice, vegetables and millet (average increase of 11%) after applying the improved FYM.

Table 5. Selected agronomic practices and the status of their scaling up.

Practice	Test farmers	HHs continuing the practice		Farmer to Farmer	HHs outside the test sites (partially supported by government/NGOs)	Total HHs following SAK practices
Yam growing in sacks	119	59	50%	196	462	717
Pumpkin on terrace wall	151	100	66%	84	101	285
Legumes on terrace edges/wall (rice bean, horse gram, cowpea)	350	238	68%	125	661	1024
Maize + cowpea intercropping	141	129	91%	118	228	475
Ginger + maize-soybean intercropping	59	58	98%	90	278	426

Millet + soybean Intercropping	45	32	71%	12	30	74
Water harvesting + Drip irrigation + Plastic house	70	58	83%	206	124	388
Improved cattle shed and farm yard manure	72	72	100%	48	102	222
Mustard + Pea intercropping	50	36	72%	45	151	232
TOTAL	**1057**	**782**	**74%**	**924**	**2137**	**3843 (~ 19,215 people impacted)**
				3061		

Tarpaulin greenhouses combined with irrigation & tarpaulin-lined ponds: income for women

The combination (kit/package) of three different SAK products (inexpensive tarpaulin greenhouse, drip irrigation, tarpaulin-lined ponds) appeared to be highly successful in areas where moisture is a limiting factor for vegetable production. Water harvesting ponds and drip irrigation enabled farmers to grow winter season vegetables inside the greenhouses which was previously not in practice due to prolonged drought. The terraces enabled the use of gravity to permit water distribution (the tank/water pond was established on an upper terrace, and the greenhouse on the lower terrace). The project initially supported 70 farmers with the kit package, costing NPR 15,000 (CAD $187) to install. It generated an average income of NPR 10,500 (equivalent to CAD $125) per household from the summer season's harvest. After harvesting the first crop (tomato), farmers planted winter season vegetables (such as summer squash, cauliflower) in the tarpaulin greenhouses. Additionally 5 crops (3 years and 6 seasons) could be harvested by using the same structure to provide significant economic returns (~NPR 30,000 i.e., CAD $375) to farmers from an area of 50 m^2. If we deduct the cost of production i.e., ~CAD $187, farmers can earn a net income of CAD $188 (NPR 15,000) over 6 cropping cycles.

Scaling up: Out of 70 households which were supported by project, 58 (83%) are continuing the practice (Table 5). This technology has been scaled up by another 50 HHs around the test sites with a partial contribution from their VDC and other projects in the region. 11 HHs have copied the test farmers with their own investment. Additionally, 195 HHs have received support from government agriculture offices and the local government. The project also demonstrated this technology beyond the project sites to 124 HHs. Furthermore, local government agencies such as VDC and DADOs have included this intervention in their annual plans for longer-term scaling up. The lessons were included in the SAK picture book for long-term scaling up (Annex 1.27).

Outcome: All the farmers want to continue the plastic house as it provides high economic return. From each greenhouse, farmers earned NPR 13,494 (CAD $169) in the summer and NPR 3500 (CAD $44) in the winter (mostly consumed by the household and shared with neighbours). 40% of farmers did not need drip irrigation/ponds as they have sufficient water for the winter.

Short duration drought tolerant legume cover crops and forages to assist female farmers

The dry season is when female farmers suffer from male outmigration (Annexes 1.46-1.47); the lack of rain reduces yield and causes shortages of forages for livestock. We identified a novel strategy for the utilization of dry season weeds (Annex 1.2, Annex 1.42) but selected three well-established drought tolerant legumes (lentil, vetch, fava bean) as dry season crops for experimental analysis given the short duration of this grant (Annex 1.15). Greenhouse trials were initiated in Nov 2015 to evaluate Nepalese lentil varieties during drought. Recommendations will be made to LI-BIRD/NARC as to which lentil varieties to scale up in future SAK legume seed kits (Annex 1.15). Another contribution (MSc student Finlay Small) was the prototyping of a novel, low-cost microcontroller based irrigation system to facilitate drought research in developing countries at a low cost (the system maintains pots at the desired moisture content by weighing them and then adding water) (Annex 1.15). This system can be replicated in Nepal and other developing nations.

3.2 Production and testing of the knowledge extension model

Promote a novel extension model:

SAK picture book: The project developed perhaps the world's most comprehensive extension picture book (145 lessons, totalling ~190 pages) of best practices and products for subsistence farmers, and conducted participatory editing with female farmers (Annexes 1.27.1-1.27.6). In Jan 2018, 500 initial copies of the complete book were printed for distribution as training materials in Nepal (agriculture extension college, farmer groups, government, school children, etc. to assist illiterate women farmers in particular. All lessons are both English and Nepali captioned. Earlier, a separate booklet containing 22 of the most promising SAK lessons for the local context were printed as booklets and distributed to 200 farmers directly to test its efficacy (Annex 1.28). The individual lessons have also been printed as flyers and included as inserts with SAK products through Anamolbiu's distribution channels. There are a few districts where the flyers were not distributed, as a control, to measure the difference in sales and efficacy compared to SAKs sold with the picture lesson inserts. Survey tools have been designed to measure the efficacy of the Nepalese SAK booklet and complete SAK books, led by PhD student Rachana Devkota. Surveys began in 2017 and are ongoing, supported by an IDRC doctoral award. The initial reveal that farmers find most lessons understandable across socio-economic groups, but complex lessons are challenging or too small; women are asking for additional lessons (e.g. proper use of chemicals). Furthermore, the picture books have been adapted to six different geographic regions (6 versions: Nepali, South Asia, Sub-Saharan Africa/Caribbean, East Asia, Latin America, North Africa/Middle East) (Annexes 1.27.1-1.27.6) and became available in Jan 2018 for free download at www.SAKbooks.com. Users are now able to freely download and mix/match individual lessons to create custom booklets. Very gratifying, we started to receive offers by email to translate the books into local languages and to use the books for local farmers (e.g. Indonesia and elsewhere).

SAK Encyclopedia: The project has created an accompanying open access eBook in which key SAK products and practices described in the picture books are critically evaluated, with helpful resources to get started. The book is intended for aid groups, governments and extension officers. The book is entitled *Encyclopedia of Subsistence Farming Solutions* – an initiative led by students at the Univ. of Guelph. An early draft of the eBook (350 pages, Annex 1.29) is available

at www.SAKbooks.com. The final book will be ~500 pages (~95 lessons) and published online in 2018, and will be updated and expanded by Manish Raizada during his career.
Mobile phones: In lieu of smart phones, the project tested the concept of using mobile phones to conduct feedback surveys with consumer farmers who purchased SAK products. A total of 1100 surveys were completed, as noted in this report. The strategy can be adopted by other projects.

Social media/YouTube: Guelph undergrad student David Borish created a 20 min mini-documentary and several short videos for individual SAK product/practices which have received a few thousand views on YouTube on the SAKGlobal Channel (https://www.youtube.com/watch?v=HTt0jvG_Yws&index=17&list=UUrkWhLffIZVpErHNWuakYkg). We have building an active Twitter following around the world (10,600 followers) (https://twitter.com/sak_nepal) . Since 2014, a total of ~500 Guelph students created social media campaigns to disseminate SAK products/practices to a broader audience, available at www.SAKNepal.org (bottom). Students also created social media resources and written reports to promote export of Nepalese agri-food products, or Canadian products to help the Nepalese agri-food industry (e.g. food processing) (www.SAKNepal.org) which was shared with Nepalese government officials and stakeholders during a trade workshop in Kathmandu on Jan 8, 2018. The project has created resources for the IDRC website and also for the Canadian Geographic website.

Books, journal articles and other publications:

To disseminate project results worldwide to professionals, we have now generated >18 published peer-reviewed articles (journal/book chapters), submitted 3 more with 18 more manuscripts in progress, along with 4 books/booklets, 5 theses (3 published, 2 in progress), 3 government reports, and 4 popular stories of change, for a total of 50+ anticipated publication outputs. The project has presented papers/posters at 23 conferences which is ongoing.

To engage youth for long-term transformation change, of both smallholder farmers and future donors in rich nations, we created 6 SAK picture books for children from farming families (Annex 1.27); wrote a chapter for a popular US textbook to target university students (Annex 1.21); and included a SAK project site picture in a Scholastic Publishing book that will be sold to >25,000 Canadian primary school children entitled, "Enchantment of the World: Nepal" (for 2018). The project has written *Stories of Change* to reach a popular audience (Annex 1.20).

Promote farmer-led hybrid maize seed production through extension training:

There are public misconceptions about hybrid corn/maize, but it is a non-GMO, natural/organic process that simply involves mating two genetically distant (inbred) varieties of corn (pollen from one variety is added to the silks of the other – very simple). For reasons that are not understood scientifically, the yields of the progeny seed (F_1), after sowing, are much higher than either parent variety. The SAKNepal project aimed to decentralize production of hybrid F_1 seeds to increase farmer incomes, initially by extension training of farmers. *We are behind schedule on this objective*. Led by Anamolbiu, the project tried multiplying parental inbred seeds received from the Nepal Agricultural Research Council (NARC) in Chitwan and Dhading districts. Initially, the production area was high (>1 ha) but the production was not encouraging, primarily due to unfavourable weather. More recently, Anamolbiu began producing F_1 maize in three different places (Jhapa, Chitwan, Nawalparasi) but the scale was lower because we are waiting for better inbred lines from NARC to be released. Currently three farmer groups are engaged and production scale is expected to be ~3000 kg. Hence the background is all set for doing this at a commercial scale by engaging more farmer groups as soon as Anamolbiu receives the appropriate inbred lines from NARC. The current market price of F_1 maize seed is Rs 300/kg which is three times higher than the open pollinated seeds. Multiple SAK picture lessons have also been created to scale up this technology (Annex 1.27), to help global farmers to produce hybrid maize seeds locally. We are nearing submission of a comprehensive journal article that describes the challenges and opportunities of farmer-led production of hybrid maize.

3.3 Testing and implementation of the scaling up model

An overview of testing and implementation of the scaling up model has been presented in Annex 1.32, 1.33, 1.40 and 1.48. The project continued to scale up the best early set of SAK products through Anamolbiu and SAK practices through different extension channels. The major headline is that we have reached 60,288 households representing up to ~ 270,000 people, which includes 56,445 households impacted by SAK tools/products (Table 6) and 3843 households adopting SAK practices such as agronomic practices (Table 5).

SAK practices: Out of 1057 test farmers, 74% are continuing these practices (Table 5), including 924 HHs without project support. Furthermore, 1986 additional HHs from outside the test sites are undertaking SAK practices, partially supported by the project or other institutions. Practices being adopted the fastest are: yam cultivated in sacks, legumes on terrace edges, maize + cowpea, and ginger + maize intercropping and the plastic greenhouse package. Total adopters for yam in sack are 717 HHs, intercropping by nearly 1000 HHs, plastic house + water harvesting by 388 HHs, legumes and pumpkins on terrace wall by 1024 and 285 HHs, respectively.

SAK products overview: Private sector scaling up was conducted via 5 distribution channels at 74 outlets in 20 districts across Nepal. Most important, unlike many development projects, the sales and scaling up are continuing even after the termination of the SAKNepal project. Distribution channels for comparative studies included: 1) peri-urban snackfood dealers, 2) agricultural cooperatives, 3) agro-veterinary dealers 4) machinery/ hardware suppliers, and 5) GO/NGOs. Except for GO/NGOs, other channels asked farmers to pay for each SAK product. The pace of marketing/sales increased significantly as compared to the last reporting year. However, the high sales figures were primarily due to pre-existing agro-vet stores (and direct bulk sales to GO/NGOs) rather than the more innovative snackfood and hardware store models, because of the time required to establish new relationships and the greater profitability of the agro-vet/GO/NGO channels – but nevertheless the innovative models have shown promise and lessons are being learned. In total, 26,000 products were sold as of January 2018 through the commercial channels, with the remainder sold to GS/NGOs (Table 6). Eight items (handheld corn sheller, vegetable composite seed kits, field rake, legume kit, hermetic grain storage bags, silpaulin sheets (to construct greenhouses, and line ponds), garden gloves and drip irrigation kit), were supplied to the commercial vendors. Out of 21,913 cornshellers distributed to the different channels, 14,928 (68%) were sold as of January, 2018. Similarly 819 field rakes (out of 1101 distributed) have sold. These data demonstrate high consumer demand. Furthermore, more units of the field rake, garden glove and fruit picker have been ordered due to increased consumer demand.

Table 6. Channel wise sales records of SAK tools/products until Dec 2017.

Item	Channel wise sales (number of item sold)						Self-paid	TOTAL (HHs)
	Agro vet	Snackfood dealers	Utensil/ hardware stores	Co-operative	Exhibitions /Events	GO/NGO		
Corn sheller	9350	525	2765	805	1483	3646	14928	18574
Veg kit	4106	45	0	310	160	20987	4621	25608
Farm rake	657	54	20	35	53	1437	819	2256
Leg kit	5025					160	5025	5185
SGB	301			150	4	3700	455	4155
Silpaulin	16	1				64	17	81
Gloves				27	63	476	90	566
Drip irrigation kit						20	0	20
Total	**19455**	**625**	**2785**	**1327**	**1763**	**30,490**	**25,955**	**56,445***

*est. 254,000 individuals impacted directly/indirectly, assuming each household had 4.5 members as suggested by the latest census in Nepal which is the overall urban/rural average; the rural average is 4.8, and our baselines surveys in the mid-hilsl suggest the number is between 5-6) and assuming 90% of households purchased 1 SAK product, and 10% purchased two SAK products.

Product comparisons: The sales records of Anamolbiu showed that 5 products (e.g., handheld corn sheller, farm rakes, super grain bags, legume kits and composite vegetable kits) which typically sold for less than NPR 300 each (i.e., USD $3) sold better compared to the higher priced products (e.g., millet thresher, drip irrigation set, silpaulin plastic sheet, cattleshed improvement and drip irrigation and plastic tunnel) (Figure 1). Hence it has become clear that low cost tools (<300 NPR) have a greater chance to be sold in the existing agro-vet and snackfood distribution models, in part perhaps because 300 NPR is within the decision-making power of women. Also, it indicates that scaling up of costly machines/equipment need a co-financing mechanism (e.g. subsidy, etc.) (Figure 2).

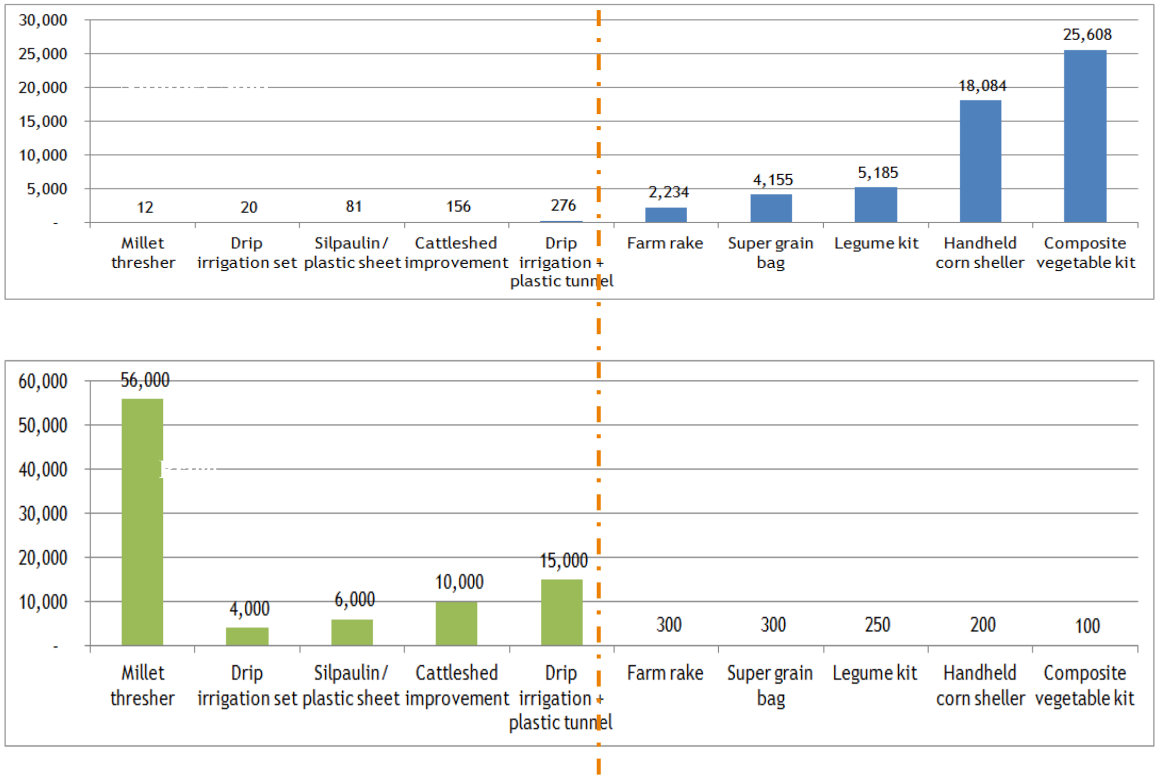

Figure 1. Association between the price of SAK products and their sales.

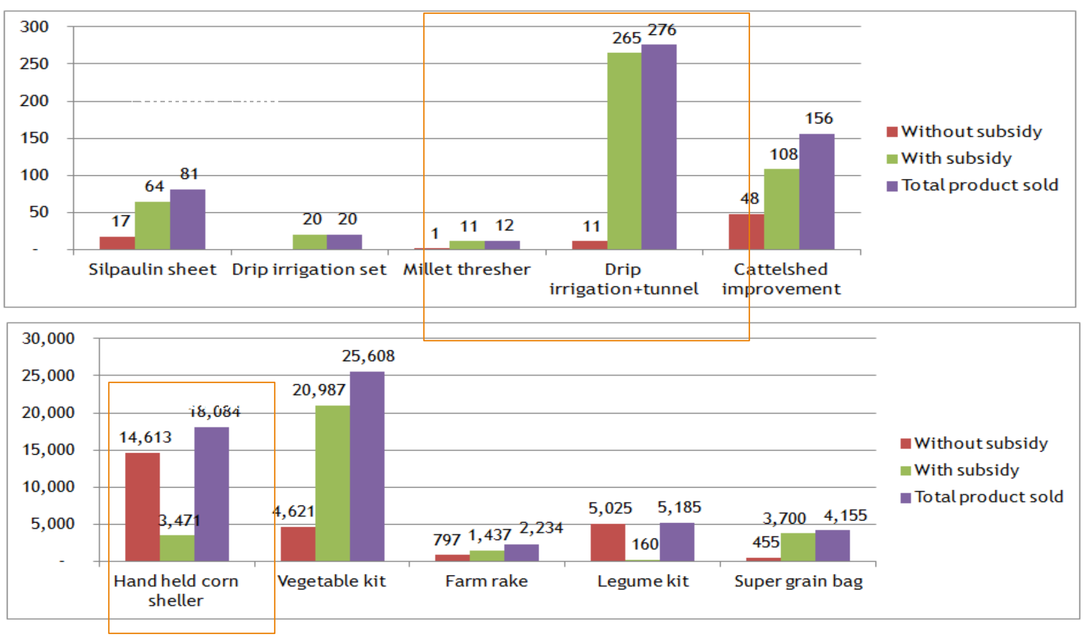

Figure 2. Association between subsidy and sales of SAK products.

Additional details on SAK product sales:

- Agrovet dealers were effective at selling all five products. These are the default outlets for supplying agricultural inputs in Nepal; hence their sales success for all products is reassuring.
- Peri-urban snack food dealers and utensil/hardware shops are the two unconventional marketing channels tested. Snack food dealers did reasonably well in selling the corn sheller and vegetable seed kits. These items are small and light weight which are compatible with snackfood distribution. Utensil/hardware shops sell kitchen utensils, plastic containers as well as traditional agriculture tools such as *kodalo* (spade) and *hasiya* (sickle) made by local blacksmiths. They were found to be most effective in selling metal products: the corn sheller and farm rake.
- Farmers' cooperatives were effective at selling super grain bags but did poorly than other channels in selling corn shellers and composite vegetable seed kits. They were also less keen on selling these items. Farmers' coops in Nepal have now shifted their priorities towards savings and credit activities, and their work hours were limited as their members are typically volunteers.
- Future sales: The above observations suggest that for distribution of SAK products, outlets that stay open year round, such as agrovets, *kirana pasal* (general purpose corner shops that receive supplies from snack food dealers) and utensil/hardware shops may be the best bet. The virtue of staying open year round means that farmers can buy seasonal items when they need. In contrast, a cooperative that does not open for business everyday will need to coordinate the date for sales. In addition to these channels, community based forest users groups (CFUGs) offer promise. For future sales, Anamolbiu will use a combination of channels appropriate for each SAK product.

Consumer feedback through cell phone surveys

As of Jan 2018, 1106 mobile phone survey responses have been collected from consumer farmers to understand the impacts of SAK products including on female drudgery (Table 7). Interestingly, the response rate was >80%, demonstrating the utility of this approach for other development projects. A journal manuscript in 2018 will report these findings. For the corn sheller and farm rakes, farmers responded well but for the vegetable kits and supergrain storage bag, we faced some difficulties to reach out to the exact users. Findings of the cell phone survey to measure the impact of scaling up of SAKs are covered in the project monitoring framework report (Annex 6).

Table 7. Cell phone survey progress.

Progress Jan 2018		Sample size for feed back survey (LoC 95%, MoE 5%)	Progress	%
Item	**Sales**			
Corn Sheller	15,000	375	445	119
Vegetable Kits	4600	355	257	72
Farm Rake	1000	280	310	111
Super Grain Bags	500	218	94	43
Total	**21,100**	**1228**	**1106**	**90**

Impacts measured through cell phone surveys

The specific project objectives, associated interventions (practices and products), their performance evaluation indicators, and response from the test farmers as well as consumer farmers collected through cell phone surveys are discussed in Annex 6. The preliminary results showed that 89%, 91% and 100% of female respondents, respectively, reported that the handheld corn sheller, farm rake and millet thresher reduced pain/physical strain (at a 'good level' among options: no, little, good and high) over traditional methods. These tools exceeded our target reduction of pain/physical strains by 50%. Average numbers of working hours reduced by these three tools (compared to traditional methods) were 34, 45 and 36 per HH per year, respectively, against the target reduction of 10 hours of labour per HH per year (Annex 6).

Impact on promotion/scaling up SAK tools

Anamolbiu has used the cell phone surveys to gain insightful information and feedback from vendors and consumers regarding the acceptance level of SAK products. The findings were also used to make strategic decisions. For instance, the first-generation table corn sheller was a complete failure, with seven purchasers returning the product back to the vendors, whereas the second-generation, handheld corn sheller received positive feedback. The vegetable composite seed kits were well received but the surveys revealed that buyers needed fewer seeds which reduced the sales price. As a new item in the list, Anamolbiu recently added the fruit picker upon the recommendation by the test and consumer farmers.

Impacts on improving nutrition through increased availability and use of legumes and vegetables

While analyzing vegetable kit buyer feedback from cell phone surveys, the average number of vegetables (i.e., diversity) grown by each household increased from 5 to 6. They survey also revealed that the vegetable kit helped consumer farmers to shift towards cultivation of more nutritious crops in their home gardens. The data showed that 35% households replaced three species, 53% households replaced two species and 55% households replaced 1 species with more nutritious vegetables. Only 8% users realized significant increases in production; however, 26% of the buyers experienced increased vegetable consumption by women and children in their family. The data further showed that 6% farmers sold part of their produce and most was used for household consumption. In addition, 90% of the users wanted to purchase the seed packages again as long it is timely available in the market. . Anamolbiu also realized that species composition (which may be specific for different regions) and timely distribution is important to achieve higher sale of the vegetable seed composite kit. In addition, over 1000 households who are growing legumes in terrace edge or risers reported that they are producing up to 40 kg grain on previously un-used terrace walls which is mainly used for family consumption (Table 5, Annex 6).

4. Synthesis of results towards AFS themes (5 pages max.):

SAKNepal activities contributed to advance with the following AFS themes:

4.1 Increasing agricultural productivity (Availability)

Where farmers practice terrace farming around the world, the horizontal cultivation area is very limited, yet there are underutilized vertical surfaces (the terrace risers/walls). The project has identified agronomic innovations and crop varieties that permit cultivation on terrace edges, vertically on terrace walls as well as on narrow terraces. With these innovations, farmers are able to harvest additional yield compared to their traditional practices. Moreover, these innovations are scalable to other parts of the world and represent a conceptual breakthrough.

Of the different agronomic interventions tested, maize + cowpea appeared to be the most productive and economic intercrop combination for the spring-summer season [26% higher total land output (TLO) than the maize sole crop with an increase of potential economic return by 64%] whereas millet + soybean appeared to be the best combination for the rainy-autumn season (26% higher TLO than the millet sole crop with a 154% increase in potential income). For the pre-winter/winter season, wheat + pea and mustard + pea combinations appeared to be productive (wheat + pea: 16% higher TLO than wheat sole crop with a 30% increase in potential income; mustard + pea: 30% higher TLO than mustard sole crop with a 12% increase in potential income). The year round intercrop system (i.e., ginger + maize-soybean) increased TLO (2% higher compared to when ginger was cultivated alone) which increased potential economic return by 11% (Table 4, Annex 1.24).

Similarly, among three wall crops tested, chayote squash appeared to be highly prolific producing up to 350 kg fruits from a single plant, and remunerative with potential economic return of up to $67 per plant. Similarly, yam and pumpkin produced 6 kg and 52 kg of tuber and fruits, respectively, generating potential income up to $5 and $12. As an edge crop, ricebean appeared to be a productive (0.43 t ha^{-1}) and remunerative (potential economic return of $436 per ha per season) which is followed by horsegram (0.32 t ha^{-1} with a potential economic return of $424 per ha per season), cowpea (0.29 t ha^{-1} with a potential economic return of $368 per ha per season) and blackgram (0.25 t ha^{-1} with a potential economic return of $298 per ha per season) (Table 4, Annex 1.25).

A key focus of the above innovations, and those described below, is to enrich the soil by promoting and optimizing legume crops that form natural symbiotic relationships with rhizobia microbes to convert otherwise unavailable atmospheric nitrogen gas into organic nitrogen fertilizer. Managing soil nitrogen on sloping terraces is always challenging. SAKNepal tried to address this challenge by testing the Guelph biosensor diagnostic technology (GlnLux) which helps scientists to compare and identify the correct type of rhizobia strain for a specific legume variety, minimally useful for pre-screening of inoculants indoors. In Nepal, LI-BIRD has now developed the capacity to conduct *GlnLux* experiments and will serve farmers by undertaking enhanced legume research in the long run to develop future SAK seed and microbial products.

With the help of the private sector, namely Anamolbiu, quality seeds of legumes and vegetable seed packages have been promoted. The project is also promoting other private sector products such as grain storage bags that help poor farmers prevent post-harvest losses from pests, or tools that sustain less strenuous farm labour (e.g. farm rake to heap manure, gardening gloves).

Though not discussed in the framework of this report, PhD student Kamal Khadka has been undertaking very innovative research aimed at improving wheat yields in Nepal, in particular to mitigate climate change. Kamal, in collaboration with Prof. Ali Navabi at Guelph, has undertaken the most comprehensive genotyping and phenotyping of ~300 wheat varieties and landraces from Nepal (and comparison lines) which has created the foundation for decades of wheat improvement to benefit Nepal – a platform for traits such as micronutrient and protein improvement to target women. Several publications and resources are anticipated in 2019; long-term his research will lead to sales of new wheat varieties for Nepal (SAK seed packages).

The SAK picture book offers many best agronomic practices to improve productivity. The book may be especially helpful to illiterate women farmers in remote regions. The team has tried to make it as participatory as possible, by engaging Nepali rural women, to ensure its usefulness. A discussed, but not implemented, scaling up opportunity exists to promote best agronomic practices by accompanying SAK seeds/tools with SAK agronomic picture lessons as flyers.

As noted above, a key focus of the project was to identify and promote products/tools that would reduce female drudgery in agriculture which may lead to enhanced productivity as well. The project identified and sold the small hand-held corn sheller, gloves, field rake, millet thresher and mini tiller, and other products, as successful interventions to reduce female drudgery. The cell phone consumer feedback survey further confirmed that the handheld corn sheller, farm rake and millet thresher helped reduce pain/physical strains at a 'good' level over traditional methods by 89%, 91% and 100%, respectively. Average numbers of working hours reduced by these three tools (compared to traditional methods) were 34, 45 and 36 per HH per year, respectively (Annex 6). An anticipated side-benefit of the corn sheller is reduced kernel damage, which in turn reduces post-harvest susceptibility to pests and pathogens. Similarly, the field rake helps to ensure complete removal of weed debris from the field that might otherwise propagate and reduce crop yields.

As already noted, the impact of these marketed products (seeds, tools, etc.) were measured by using self-reporting data with respect to enhancing productivity, reducing hours of labour, etc. at project test sites as well as via feedback surveys with consumer farmers using cell phones.

4.2 Improving access to resources, and /or markets and income (Accessibility)

Nepal is one of the poorest regions of the world, with large numbers of families below the $1-$2 per day threshold. In the past, most development projects in Nepal tried to bring change by sharing technology (inputs) to farmers for free. But when these projects terminated, farmers did not know where to purchase products from, the price, how to approach a supplier and manage transport. SAKNepal is trying to increase farmer access to effective technologies by making them available in their communities, through the stall franchises of agricultural companies, snackfood dealers, local machine/utensil shops and agro-vet dealers. As any individual household has different needs, SAKNepal has provided access to a menu of dozens of technologies and agronomic practices, from which farmers can choose from, to improve income and overall well-being. The menu-choice approach ensures that large numbers of households are being impacted. As of Jan 2018, we estimate that 60,000+ households, or up to 270,000+ people, have been impacted, directly or indirectly, and though the project has officially terminated, sales are continuing by Anamolbiu. It will be interesting to measure impacts 3-5 years from now.

To improve farmer incomes, though behind schedule, SAKNepal has been trying to build capacity of farmer groups to produce hybrid maize/corn seeds. One direct beneficiary includes producer farmers who will earn at least four times more money for hybrid seeds. Secondly the increased availability of quality hybrid maize seeds will boost maize yields, while allowing farmers to be more self-reliant from institutions, especially in mountainous regions.

Similarly, the project has promoted vegetable production in tarpaulin greenhouses as well as production of legumes and cash crops (e.g. yam on terrace walls, high value vegetables). These directly support farmers to increase their cash income. The SAK picture book has a value addition section and other ideas to promote local income generation and empower entrepreneurs.

4.3 Improving nutrition (Utilization)

Poor households typically have a carbohydrate-rich, but protein-deficient diet, and suffer from micronutrient deficiencies, leading to permanent stunting, as well as immune, vision and IQ deficiencies. As noted above, SAKNepal has been using innovative (and traditional) agronomic approaches (e.g. legume rotations) on terraces (e.g. at terrace edges) to promote high value legumes to alleviate protein deficiencies, as well as packets of seasonal vegetables to alleviate micronutrient deficiencies. Specifically, legumes are not only good sources of amino acids Lys, Met and Trp, but also calcium, iron, nicotinic acid, and thiamin, which complement staple cereals in their diets. On the other hand, composite packets of vegetable seeds offer farmers an opportunity to grow diverse vegetables in their home/kitchen gardens to improve the availability of micronutrients including beta carotene, folic acid, zinc and iron. Consumption of pulses and vegetables, including wall growing chayote (a squash high in folic acid and the essential amino acid tryptophan), help improve maternal health and family nutrition.

Quantitatively, as of January 2018, the commercial pipeline has sold these seed kits to ~9646 households (4621 vegetable seed kits and 5025 legume seed kits), likely impacting >43,000 people. These numbers when combined with the seed kits supported by other GO/NGOs (who purchased seed kits from Anamolbiu) reached to 30,793 (25,608 vegetable seed kits and 5185 legume seed kits) impacting > 135,000 people (Table 6). Consumers who purchased vegetable seed kits from the market have added at least one species to their home gardens and many of them changed their species composition, obtaining more diverse nutrients (see section 4.3)

More than 1000 households are growing legumes on terrace walls (Table 5). Another 975 households are now growing legumes as intercrops with other main crops. Households which are growing legumes on terrace walls produced 40 kg grain and all the households used the total increased production for family consumption.

In addition to the above lessons, the SAK picture book also has lessons focused on pregnant women and children with respect to consumption of legumes (for example, eating of small grained lentils improves iron uptake), small grains (e.g. finger millet), colourful fruits/vegetables (high in vitamin A), and leafy greens and dietary techniques to improve absorption of iron (e.g. avoiding caffeine at mealtime). Similarly, promotion of rhizobia/*GlnLux* techniques maximize nitrogen fixation in legumes which in turn increase the protein content of the grain.

4.4 Informing policy

First, SAKNepal did not initially plan to focus on this AFS theme, though we have connected with national level policy makers through joint field monitoring visits and other events. LI-BIRD has also been lobbying for the integration of SAK technologies into the government's regular programmes as well as other development concepts (e.g. climate smart village, machinery subsidies). In fact, following invitations to an earlier SAKNepal meeting and demonstrations of SAK technologies in the field, DADOs and the Prime Minister Agricultural Modernization Project (PMAMP) also started including SAK products/practices in their regular programmes, such as the corn sheller. Furthermore, the project has submitted a comprehensive journal analysis of Nepal's mechanization policies with respect to women and the mid-hills region to assist policy makers (Annex 1.34) and organized a high-level governmental trade workshop in Jan 2018.

Second, in this project, a partnership model was tested between a research based civil society organization (CSO) and private seed company for scaling up of low cost sustainable agriculture technologies – which did have policy implications. Here, the major role of the CSO was testing SAK products and interventions and providing suggestions/recommendations as to where to obtain products from, and the company procured and distributed the products. This partnership model appears to be successful: the CSO (LI-BIRD) tested products from different sources with farmers, and then the company (Anamolbiu) purchased a subset of the successful products in bulk, undertaking the marketing, sales and distribution. Anamolbiu has now included SAKs as a part of their business portfolio and has included in its overall marketing strategy. This has drawn the attention of policy makers as an exemplary scaling up model to replicate in other regions.

The project has published academic and policy papers, in journals and at conferences, to influence public policy and created online knowledge resources such as the SAK picture book and Encyclopedia and Stories of Change, etc. We have been using our 10,600 Twitter followers around the world to spread a mini-documentary, short-video clips, the SAK picture book and other resources we created about the SAKNepal strategy. The next phase should be to franchise the SAK model to other countries especially in Sub-Saharan Africa.

5. Project outputs/publications (Objective-wise)

The project has developed ~55 publications (e.g., peer reviewed manuscripts, books and booklets, conference proceedings, etc.) as well as other dissemination materials/videos to disseminate project findings to the farmers, researchers, extension workers and policy makers in Nepal as well as other developing countries (Please refer to Annex 1). In compliance with IDRC policies, the outputs generated by the project have been made available through open access or other publicly available resources:

Objective 1: On-farm testing and improvement of >40 SAK products and practices

- To disseminate the project results globally, the project is in the process of generating 37 publication outputs (21 published, 3 submitted and ~13 in preparation) including peer-reviewed journal manuscripts and short communications (30), books/book chaptors (2), MSc/PhD theses (4), and impact stories of change (1) (Please refer to Annex 1.1-1.26).

Objective 2: Production and testing of the knowledge extension model

- The project is in the process of generating 12 publication outputs (8 published and 4 in preparation) including 6 versions (e.g., Nepali, South Asian, Sub-Saharan Africa/Caribbean, East Asia, Latin America, North Africa/Middle East) of the world's most comprehensive picture books of best practices/ products for subsistence farmers, 2 peer-reviewed journal manuscripts and 1 PhD theses (Please refer to Annex 1; 1.27-1.29). The picture books have been created, tested with female farmers, and published to assist illiterate women farmers in particular (150 lessons, totaling ~190 pages) which are now available for download at no cost (http://www.sakbooks.com), which may be mixed/matched to create customized booklets. A parallel written book (*Encyclopedia of Subsistence Farming Solutions*) that describes and critically evaluates >100 SAK products/practices (currently ~350 pages) is now online (draft, at www.SAKBooks.com) to help people in other nations to understand/adopt SAKs.

Objective 3: Testing and implementation of the scaling up model

- In addition to the publication noted above, the project is in the process of generating 9 publication outputs (4 published, 1 submitted and 4 in preparation) including 5 peer-reviewed journal manuscripts and 2 storied of change, and 1 report to international community (Please refer to Annex 1; 1.30-1.34).
- Beside publication, nearly 500 Canadian Youth Agri-Food Trade Ambassadors have identified, evaluated and promoted ~500 unique bi-lateral trade opportunities between Canada and Nepal.
- The project successfully organized a national level workshop on 'Agro-based trade between Nepal and Canada' on Jan 8, 2018 to catalyze bilateral trade between our two nations. In total, 44 participants, including high level dignitaries, attended the event, including representatives of the trade sector, academia, the Government of Nepal and NGOs.

6. Problems and challenges (1 page max.):

The project faced a major Earthquake, hail storms and an extended fuel blockade, all of which affected field testing and commercial scaling up. These were mitigated via a 12-month project extension which was greatly appreciated.

The preliminary idea of the project was 'if the product is useful and affordable, we would make them available at local stores so that farmers can buy and use it'. Hence we previously considered the distribution mechanism as the major constraint in the process and wanted to address this component through the project. But our realization later was that farmers need to know about the product, the value of using it, and the place where it is available. Therefore, the project decided to adopt different strategies for products and practices, and tried accordingly. Still adoption of SAK practices (as compared to SAK products) was not as high as expected. The main challenge was, unlike tools, demonstration of practices required more time and financial investment. When information was shared only through the media (e.g. SAK pictures), without a live demonstration, farmers did not try aimproved technology but once they saw it live or tried it by themselves they wanted to keep it. Therefore, in the final year of the project, we focused on demonstration of the champion SAKs to other areas/surrounding villages (beyond test farmers) with the help of Anamolbiu and other NGOs, which helped increase rapid adoption and hence positively impacted the sales of SAKs.

Another challenge was observed when government agencies (such as DADO) distributed similar products with heavy discounts, following field visits with our project staff. One example was seen with corn shellers wherein DADO in Kaski sold corn sellers with a 90% subsidy. Our actions to tackle with this situation were:

1. Intensification of advertisements and consumer awareness; Anamolbiu diversified the means of knowledge transfer (advertising tools).
2. Anamolbiu focused on public interaction events like exhibition/fairs so that they could meet consumers directly and pass the message.
3. Anamolbiu hired and mobilized marketing executives (2 staff); though these were short term positions, Anamolbiu also continued to mobilize marketing executives at the local level to increase interactions with consumers as well as vendors to pass accurate messages about SAK products.
4. Anamolbiu began to focus on profitable, bulk purchasers of SAK products (agro-vet dealers and government/NGOs), while they built other capacity (e.g. snackfood dealers).
5. The project used findings from consumer feedback surveys to improve the distribution system and tried to address other issues raised by consumers to improve marketing.

At Guelph, some financial challenges were observed after the no-cost 12-month extension (which was previously anticipated) and pro-active measures were taken. In particular, the 12-month project extension caused challenging salary liabilities (especially for the Canadian SAKNepal project coordinator and GlnLux postdoc). Manish Raizada wrote several Ontario-focused grants to transition these positions to other grants which also reduced their service to this project after April, 2017, but with only limited success. Furthermore, the project is publishing many more papers than expected (~50), but as publication costs are high, especially open access to reach developing countries, this has caused a budgetary strain; disseminating project results at international conferences suffered as a result. To accommodate these challenges, we could not invite representatives from 12 terrace farming nations to Nepal. Furthermore, the $20,000 allocated to allow the SAK Encyclopedia to be open access was re-allocated, and Manish Raizada instead chose to publish the book online as an eBook which offered future flexibility for updates. IDRC scholarships were received for the two PhD students on this project (Rachana Devkota and Kamal Khadka) to facilitate field work, as well as local grant funding.

7. <u>Overall assessment (1/2 page)</u>

In 3.5 years, this project has impacted up to 271,296 people belonging to smallholder farming households and has done so in the mid-hills of Nepal which encompasses some of the remotest regions of the world. The project achieved this level of success through an innovative partnership between a local NGO, a spin-off company with academic and government partners including engaged IDRC project staff. In particular, the spin-off company model was shown to be very successful for scaling up. The project was also successful because of its emphasis on low-cost, affordable commercial products, and by focusing on reducing female drudgery. Both of these points were exemplified by the handheld corn sheller, a $2 CAD device which has now sold tens of thousands of units in remote Nepal rapidly – because it is affordable and reduces many hours of female drudgery. Such portable, low cost products encourage farmers to start on the innovation pipeline, which ultimately liberates the time of women, which over time, will allow them to focus on education, investments in their children and improving family income and health. Commercial sales as the focus also ensured that the products were truly needed – otherwise sales would have stopped. Allowing farmers to choose from a menu of options (the "kit" approach) also allowed farmers to choose what they needed, so that there was "something for everyone". The project was also successful because it took advantage of pre-existing distribution channels that reach village-level stalls. Finally, this project has potential for future scaling up beyond Nepal by having created extension resources for illiterate women, in particular picture books, which will allow the products and agronomic innovations to be scaled up globally in a franchise model – this opportunity will require future funding. The true impacts of this project will likely be realized on a 5-year time scale which will also require additional funding.

Annex 1: Objective based project outputs in terms of publications.

On-farm testing and improvement of >40 SAK products and practices (Objective 1):

SN	Title/topic	Lead Author(s)	Update
Published Articles/Book Chapters			
1.	Agronomic challenges and opportunities for smallholder terrace agriculture in developing countries	Tejendra Chapagain and Manish Raizada	Published: *Frontiers in Plant Science* 8: 331 (March, 2017) See Annex 1.1
2.	Mitigating dry season food insecurity in the subtropics by prospecting drought-tolerant, nitrogen-fixing weeds	Finlay Small and Manish Raizada, Guelph	Published: *Agriculture and Food Security 6: 23 (March, 2017).* See Annex 1.2
3.	A meta-analysis of the effectiveness of diverse rhizobia inoculants on soybean traits under field conditions.	Malinda Thilakarathna and Manish N Raizada	Published *Soil Biology and Biochemistry*, 105: 177-196 (January, 2017). See Annex 1.3
4.	A Biosensor-Based Leaf Punch Assay for Glutamine Correlates to Symbiotic Nitrogen Fixation Measurements in Legumes to Permit Rapid Screening of Rhizobia Inoculants under Controlled Conditions *(relevance: proof of concept GlnLux paper)*.	Malinda Thilakarathna, Nick Moroz and Manish N Raizada	Published *Frontiers in Plant Science* 8: 1714 (October, 2017). See Annex 1.4
5.	Root hair-endophyte stacking (RHESt) in finger millet creates an unusual physico-chemical barrier to trap *Fusarium graminearum (relevance: a probiotic microbe from finger millet reduces need for chemical pesticides using a remarkable, novel mechanism; has potential as an organic pesticide for coating onto seeds as a future SAK product)*.	Mousa WK, co-authors and MN Raizada	Published: *Nature Microbiology*, September 26, 2016, 1: 16167. http://www.nature.com/articles/nmicrobiol2016167 See Annex 1.5
6.	Characterization of antifungal natural products isolated from endophytic fungi of finger millet (*Eleusine coracana*) *(relevance: identification of novel bio-fungicides as potential future SAK products)*.	Mousa WK, Schwan A and MN Raizada	Published 2016 in *Molecules* 3 21(9) See Annex 1.6
7.	A review of nutrient management studies involving finger millet in the semi-arid tropics of Asia and Africa.	Malinda Thilakarathna and MN Raizada	Published 2015: *Agronomy* 5: 262-290. See Annex 1.7
8.	Whole plant acclimation responses by finger millet to low nitrogen stress *(relevance: related to the environmental benefits of finger millet)*.	TL Goron, VK Bhosekar, C Shearer, S Watts, MN Raizada	Published 2015: *Frontiers in Plant Science* 6: 652. See Annex 1.8
9.	Genetic diversity and genomic resources available in the small millet crops to accelerate a New Green Revolution *(relevance: paper discusses the drought resiliency of the millets and how to improve it)*.	Travis L. Goron and Manish N. Raizada	Published 2015: *Frontiers in Plant Science* 6: 157. See Annex 1.9
10.	Growth in Turface® clay permits root hair phenotyping along the entire crown root in cereal crops and demonstrates that root hair growth can extend well beyond the root hair zone *(relevance: related to the environmental benefits of finger millet)*.	Travis L. Goron, Sophia Watts, Charles Shearer, and Manish N. Raizada	Published 2015: *BMC Research Notes* 8:143. See Annex 1.10
11.	An endophytic fungus isolated from finger millet (*Eleusine coracana*) produces anti-fungal natural products *(relevance: a probiotic*	Mousa WK, Raizada MN and co-authors (2015)	*Published 2015 in: Frontiers in Microbiology* 6, 1157. See Annex 1.11

	microbe isolated from finger millet can be coated onto seeds to stop fungal disease without pesticides as a future SAK product).		
12.	Draft genome sequence of Enterobacter sp. strain UCDUG_FMILLET (Phylum Proteobacteria) *(relevance: a probiotic microbe isolated from finger millet can be coated onto seeds to stop fungal disease without pesticides)*.	Cassandra L. Ettinger, Walaa M. Mousa, Manish N. Raizada, Jonathan A. Eisen	Published 2015 in: *Genome Announcements* 3: e01461-14. See Annex 1.12
13.	Natural products and molecular genetics underlying the antifungal activity of endophytic microbes *(relevance: chapters on probiotic microbes from finger millet that reduce need for chemical pesticides)*.	Walaa Mousa, Guelph	PhD thesis (Submitted Feb 17, 2016). See Annex 1.13
14.	Phenotyping nitrogen responses in maize and finger millet using root morphometrics and biosensor analysis	Travis L. Goron	PhD thesis (Submitted: July, 2017). See Annex 1.14
15.	Identifying and screening genetic resources for the development of drought-tolerant annual legume crops.	Finlay Small, Guelph	Master thesis (Submitted: September, 2017). See Annex 1.15
16.	Yam on terrace walls	Bhawana Ghimire and co-authors	Published in *Low External Input Sustainable Agriculture* (LEISA) 2016, 18: 23-25. See Annex 1.16
17.	Farmers' seed networks and agrobiodiversity conservation for sustainable food security: A case from the mid-hills of Nepal.	Rachana Devkota, and co-authors	Published 2015: *International Journal of Biodiversity Watch* (July 2015). See Annex 1.17
18.	Balancing food security and household wellbeing in Nepal's rapidly changing agrarian landscape.	Hom Gartaula and co-authors	Published 2016: *Agriculture and Human Values.* See Annex 1.18
19.	Impact assessment of women-friendly interventions in finger millet cultivation in Nepal.	Rachana Devkota and co-authors	Book Chapter, published Feb 2016. See Annex 1.19
20.	Sustainable agriculture kits (SAKs) reduce drudgery and increase farm income.	S. Sthapit, R. Pudasaini and MN Raizada	Story of Change published and disseminated in January 2018. See Annex 1.20
21.	Challenges and solutions for subsistence farmers (includes overview of SAK products/practices)	Manish N. Raizada	Popular U.S. undergraduate textbook, Plants, Genes and Agriculture - published Oct 2017 See Annex 1.21
Submitted Manuscripts			
22.	Review on climbing legumes (globally) with a case study about Nepal.	Jaclyn Clark and Manish N. Raizada	Submitted August 2017 to *Frontiers in Plant Science*, See Annex 1.22
23.	Visualizing symbiotic nitrogen fixation output from nodulated root systems by placement on agar embedded with companion biosensor cells.	Malinda Thilakarathna and MN Raizada	Submitted to *Frontiers in Microbiology* (Jan 19, 2018). See Annex 1.23
24.	Seasonal and year-round intercropping systems for smallholder farmers: Results from on-farm trials on terrace in Nepal on maize, millet, mustard, wheat and ginger.	Tejendra Chapagain, Bhawana Ghimire, Roshan Pudasaini, MN Raizada and co-authors	Submitted to Field Crops Research in March 2018. See Annex 1.24
Manuscripts in Progress			
25.	The underutilized terrace wall (riser) can be intensified to improve farmer livelihoods: case study from Nepal on-farm trials.	Tejendra Chapagain, Bhawana Ghimire, Manish Raizada LI-BIRD co-authors	For submission in June 2018. See Annex 1.25
26.	Effects of micronutrients and rhizobia bacteria	Malinda Thilakarathna,	For submission in May/June 2018.

	on Nepalese legumes.	Tejendra Chapagain, , Bhawana Ghimire, Roshan Pudasaini, MN Raizada and co-authors	See Annex 1.26
27.	Agronomic constraints and opportunities for hillside/terrace farmers in Nepal – results of RESMISA SAK survey.	Kamal Khadka and co-authors	Data currently being summarized. For submission in June 2018.
28.	Review on machinery for hillside and terrace farming with a focus on women farmers.	Austin Bruch and Manish N. Raizada	For submission in June 2018.
29.	Gender review manuscript draft on current state and progress of female drudgery (or more generally) on hillsides/terraces.	Hom Gartaula and Kirit Patel, Canadian Mennonite University	For submission in June 2018.
30.	Review on improving South Asian micronutrient malnutrition with a focus on pregnant women and children.	SaraWyngaarden and MN Raizada	For submission in June 2018.
31.	An inexpensive, open-hardware platform for precision irrigation and simulation of drought stress in potted plants: Application to Nepalese vetch.	Finlay Small and MN Raizada	Included in MSc thesis, Annex 1.15 above - Chapter 3). For journal submission in June 2018.
32.	Phenotyping Nepalese lentil varieties for resilience under drought (*relevance:* to select best lentil varieties for SAK seeds)	Finlay Small and MN Raizada	Included in MSc thesis, Annex 1.15 above - Chapter 4). For journal submission in June 2018.
33.	Use of GlnLux imaging to detect nematode and other physical damage in legume nodules and root systems *(relevance: proof of GlnLux technology)*	Malinda Thilakarathna, Manish N Raizada	Draft under revision. For journal submission in Fall 2018.
34.	Use of GlnLux imaging to detect effects of defoliation (grazing) on forage legumes (relevance: proof of GlnLux technology)	Malinda Thilakarathna, Manish N Raizada	Draft under revision. For journal submission in Fall 2018.
35.	Evaluation of a menu of low cost products to improve farmer livelihoods: Case study from terrace farmers in Nepal.	Bhawana Ghimire, Roshan Pudasaini, Tejendra Chapagain, MN Raizada, Ram Rana, Rachana Devkota, Khem S, and LIBIRD co-authors	For late 2018.
36.	Short Perspectives Article (2000 words): The corn (maize) grain sheller as a low cost tool to reduce female drudgery rapidly on a large scale.	Rachana Devkota Bhawana Ghimire Manish Raizada	For late 2018.
Please also note that a PhD thesis by Kamal Khadka is expected in 2019 in this category (for future improved wheat seeds)			

Production and testing of the knowledge extension model (Objective 2):

SN	Title/topic	Lead Author(s)	Update
Published			
37.	Picture Book of Best Practices for Subsistence Farmers (SAK Picture Books, total 5 x 190 pages): --South Asian Version (English and Nepali) --East Asian Version --Sub-Saharan Africa and Caribbean Version --Latin American Version --North Africa/Middle East Version	Lisa Smith and Manish Raizada	6 regional versions completed; farmer-edited version will be available online at www.SAKbooks.com See Annex 1.27.1 (for South-Asia version, English), Annex 1.27.2 (for South-Asia version, Nepali), Annex 1.27.3 (East Asia), Annex 1.27.4 (Sub-Saharan Africa and Caribbean), Annex 1.27.5 (Latin America), Annex 1.27.6

			(Middle East/North Africa).
38.	Picture Booklet of Best Practices for Subsistence Farmers (40 pages, in Nepali)	Lisa Smith, Rachana Devkota and Roshan Pudasaini, Manish Raizada,	Printed and distributed to farmers and extension agents in Nepal. See Annex 1.28
39.	Picture Booklet of emergency sustainable agriculture kit (eSAK) interventions following the Nepal earthquake (in Nepali).	Lisa Smith and Manish Raizada	Completed 2015 and distributed to ~100 stakeholders electronically.
In Progress			
40.	Encyclopedia for Subsistence Farmers (~95 chapters expected, ~550 pages); each chapter explains and critically evaluates an individual SAK product or practice in plain language for NGOs, extension officers, the private sector and farmer groups; open access book and database posted as individual chapters online.	Manish Raizada (editor)	60 chapters are completed and 35 additional chapters have been drafted as of Dec 2017 but not yet included. Draft available to download at www.SAKbooks.com See Annex 1.29
41.	Review/perspectives journal on prospects, constraints and methodology for farmer-led production of hybrid maize seeds.	Kamal Khadka, Guelph (lead)	For submission in June 2018.
42.	Evaluation of the Sustainable Agriculture Kit (SAK) Picture Book for Subsistence Farmers in the mid-hills of Nepal.	Rachana Devkota, Manish Raizada, Lisa Smith, Roshan Pudasaini, Bhawana Ghimire, LIBIRD co-authors	For submission in mid-2018.
Please also note that a PhD thesis by Rachana Devkota is expected in 2019 in this category			

Testing and implementation of the scaling up model (Objective 3):

SN	Title/topic	Lead Author(s)	Update
Published Manuscripts on Post-disaster Strategies			
43.	Impacts of natural disasters on smallholder farmers: Gaps and recommendations (describes *emergency SAK* (eSAK) products and practices and picture lessons and how to scale up after a disaster)	Tejendra Chapagain and Manish Raizada	Published: Agriculture and Food Security 6: 39 (May, 2017) See Annex 1.30
44.	Top 10 interventions to help farmers in Nepal after the 2015 earthquake.	MN Raizada, T Chapagain, K Khadka	Report submitted to the Canadian Department of Global Affairs (May 22, 2015). See Annex 1.31
45.	Testing and scaling up of sustainable agriculture kits.	S. Sthapit and R. Pudasaini	Story of change; published and disseminated in January 2018. See Annex 1.32
46.	A model for NGO and private sector partnership for scaling up SAKs.	R. Pudasaini and S. Sthapit	Story of change; published and disseminated in January 2018. See Annex 1.33
Submitted Manuscript			
47.	In search of responsible agricultural mechanization innovation pathways: A critical analysis of Nepal's hillside farm mechanization policies (relevance: critical analysis of policies to enable scaling up of mechanization).	Rachana Devkota*, Laxmi Prasad Pant, Hom Gartaula, Kirit Patel, Helen Hambly-Odame, Balaram Thapa and Manish N. Raizada	Initially submitted July 2017 to *Food Policy* but resubmitted Jan 20, 2018 to *Journal of Responsible Innovation* See Annex 1.34
Manuscript in Progress			
48.	Review: The Sustainable Agriculture Kit (SAK) Strategy as a Framework for Development.	Manish Raizada (lead) and co-authors	For late 2018
49.	Opportunities for wealthy nations to sell empowering private sector products to the	Manish Raizada	For late 2018

	world's 2 billion smallholder farming families (short perspectives paper).		
50.	Commentary: Internet shopping for subsistence farmers – a new era for international development?	Manish Raizada and co-authors	For late 2018
51.	A private sector-NGO business model for commercial scaling up of low cost products and practices to smallholder farmers: Case study from the SAKNepal project.	Roshan Pudasaini, Amamolbiu, Balaram Thapa, Kevin Tiessen, CMU, LIBIRD, Manish Raizada and co-authors	For mid 2018.

Outputs organized by active engagement with other Nepali and global NGOs (all noted above)

SN	Title/topic	Lead Author(s) + Venue	NGO Engagement
1.	Shared publication: Impacts of natural disasters on smallholder farmers: Gaps and recommendations	Tejendra Chapagain and Manish Raizada Published: *Agriculture and Food Security* 6: 39 (May, 2017) See Annex 1.30	Mailed to ~100 stakeholders around the world in summer 2017 including Nepali and Global NGOs and government aid agencies
2.	Shared Report: Top 10 Inexpensive Interventions to Help Farmers in Nepal After the 2015 Earthquake.	T. Chapagain, K. Khadka and MN Raizada; a report prepared for the Canadian Department of Foreign Affairs, Trade and Development (June 23, 2015), can be downloaded at www.SAKNepal.org See Annex 1.31	Mailed to ~100 stakeholders around the world in 2015 including Nepali and Global NGOs and government aid agencies

Outputs organized by youth engagement (for long-term transformational change) (most noted above)

SN	Title/topic	Target Age	Online Links and Notes
1.	"Enchantment of the World: Nepal" children's book	Elementary school children	Scholastic Books Canada will feature a picture from the SAKNepal project, for publication in 2018. The initial print run will be 25,000 books.
2.	Picture Booklet of emergency sustainable agriculture kit (eSAK) interventions following the Nepal earthquake (in Nepali)	Elementary-high school students	Completed 2015 and distributed to stakeholders electronically
3.	Picture Booklet of Best Practices for Subsistence Farmers (40 pages, in Nepali)	Elementary-high school students	Completed 2016, printed and distributed to farmers and extension agents in Nepal
3.	Textbook chapter in plain language: *Challenges and solutions for subsistence farmers* (MNRaizada)	Undergrad students	Chapter for popular U.S. undergraduate textbook, <u>Plants, Genes and Agriculture. Published Oct 2017</u> - Annex 1.21
5-9.	Picture Book of Best Practices for Subsistence Farmers (SAK Picture Books, each 190 pages, 5 regional versions): • South Asian Versions (Nepali and English) • East Asian Version • Sub-Saharan Africa Version • Latin American Version	Elementary-high school students	5 versions completed; farmer-edited version will be available online as books and individual lessons at www.SAKbooks.com (totalling ~875, pages) Annex 1.27.1 – South Asia (English) Annex 1.27.2 – South Asia (Nepali) Annex 1.27.3 – East Asia Annex 1.27.4 – Sub-Saharan Africa and Caribbean Annex 1.27.5 – Latin America

	• North Africa/Middle East Version (shorter, 117 pages)		Annex 1.27.6 – North Africa/Middle East
10.1	Canadian Youth Agrifood Trade Ambassadors (CYAFTA) – resources to promote Canadian exports and Nepalese exports created by ~500 Guelph undergraduates	Under-graduates	Linked at: http://saknepal.org/cfa-resources/ --Canadian Youth Agri-Food Trade Ambassadors (CYAFTA - ~500 social media campaigns, including Twitter, Facebook, YouTube, Instagram, etc. to promote Nepalese agrifood exports to Canada and Cdn agrifood exports to Nepal; -additional social media promotion of low cost technologies and practices for subsistence farmers
10.2	Canadian exports and Nepalese exports – YouTube videos created by Guelph undergraduates	Under-graduates	* Individual videos promoting Canadian and Nepalese agrifood companies and export ideas: https://www.youtube.com/channel/UCIPxEJqiODhxxgdms4dwgGw/videos?sort=dd&view=0&shelf_id=0 • Combined view count: >15,000 as of January 2018.
11.	~100 SAK component videos and social media campaigns	Undergrads	Guelph students have been creating social media campaigns for individual SAK products/practices and practices. Available at: http://saknepal.org/cfa-resources/

Selected posters and oral presentations in national/international conferences and seminars

SN	Title/topic	Lead Speaker (s)	Event(s)
1.	Finger millet probiotics and Sustainable Agriculture Kits in Nepal	M.N. Raizada and co-authors	Invited lecture, John Innes Centre and Sainsbury Laboratory, Norwich, U.K (Institute Seminar Speaker), March 2, 2018 Annex 1.51
2.	Sustainable Agriculture Kits (SAKs): Scaling up agricultural innovations to improve the livelihoods of smallholder terrace farmers in Nepal	M.N. Raizada and co-authors	Invited lecture, John Innes Centre Centre and Sainsbury Laboratory, Norwich, U.K., March 1, 2018 Annex 1.52
3.	Sustainable Agriculture Kits in Nepal	M.N. Raizada and co-authors	Lecture, IDRC, Ottawa, Sept 14, 2017 Annex 1.53
4.	Finger millet probiotics	M.N. Raizada and co-authors	Invited lecture, University of California at Berkeley (2017) (Department of Plant and Microbial Biology Seminar Series), October 25, 2017 Annex 1.54
5.	Finger millet probiotics	M.N. Raizada and co-authors	Invited lecture - Chair's Choice Plenary Lecture (2017), 29th Fungal Genetics Conference (Genetics Society of America), Asilomar, California, USA, March 17. Annex 1.55
6.	Presentation: Evaluating drought tolerance and nitrogen fixation in lentil accessions from Nepal and Canada	Finlay Small and MN Raizada	. 33rd Annual Plant Sciences Graduate Student Symposium (PSGSS). April 1, 2017. University of Saskatchewan, Saskatoon, Canada.
7.	Transition in mechanization of hillside farming for gender and socially inclusive rural development: A case study of agricultural mechanization policy in Nepal.	*Devkota, R., Fitzsimons, J., Gartaula, H., Raizada, M., Pant, L.P., Patel, K., Hambly-Odame, H. & Gauchan, D.	10th International Conference on Agriculture & Horticulture. Octiber 02-02, 2017, London, UK. Agroctechnology, 6 (4). DOI: 10.4172/2168-9881-C1-028
8.	Women, sustainable agriculture kits and food security in Nepal.	*Devkota, R., Raizada, M., Gartaula, H., Patel,	2nd International Conference on Food Security and Sustainability, June 26-27, 2017, San Diego, USA. J Food Process Technology, 8 (5).

		K., Pudasaini, R., Ghimire, B. & Hambly-Odame, H.	
9.	Participatory field testing of picture lessons among women farmers in 21st century: A case study from Nepal.	*Devkota, R., Raizada, M., Smith, L. Pudasaini, R. & Hambly-Odame, H.	Presented at Canadian Communication Association (CCA) Annual Conference. May 30-June 2, 2017, Ryerson University, Toronto**.**
10.	Phenotyping of a Nepali Spring Wheat (*Triticum aestivum* L.) Diversity Panel for Dark-adapted Leaf Epidermal Conductance.	Khadka, K., H.J. Earl, M.N. Raizada and A. Navabi.	Poster presented at the 88th Annual Meeting of the Cdn Phytopathological Soc (CPS) and Canadian Society of Agronomy (CSA), June 18-22, 2017, Winnipeg, Canada.
11.	Optimizing biological nitrogen fixation inexpensively as part of a sustainable agricultural kits (SAKs) strategy to assist subsistence farmers.	MN Raizada and co-authors	Speaker in Emerging Technologies for Global Food Security Conference, SK, Canada (2016). See Annex 1.35.
12.	Low cost sustainable agricultural kits (SAKs) as an agronomic strategy to improve farmer livelihoods in Nepal.	Tejendra Chapagain and co-authors	Presented in ASA-CSSA-SSSA annual meeting in Minneapolis, MN (2015); and CSA annual meeting in Montreal, ON (2016). See Annex 1.36.
13.	A whole cell biosensor (GlnLux) to measure and visualize symbiotic nitrogen fixation in legumes.	Malinda Thilakarathna and co-authors	Paper presented in ASA-CSSA-SSSA annual meeting in Minneapolis, MN (2015); and CSA annual meeting in Montreal, ON (2016). See Annex 1.37**;** Poster presented in Nitrogen Fixation Congress in CA (2016). See Annex 1.38.
14.	Testing of business models to scale up low cost sustainable agriculture practices and tools in hills of Nepal.	Roshan Pudasaini and co-authors	Presented in Climate Smart Agriculture workshop in Kathmandu, Nepal (2016). See Annex 1.39.
15.	New manual step seeder for subsistence maize farmers.	Austin Bruch and MN Raizada	Presented in departmental conference in University of Guelph, ON (2016). See Annex 1.40.
16.	Phenotyping of Nepali spring wheat genotypes for traits associated with drought tolerance.	*Khadka, K., M.N. Raizada and A. Navabi.	Poster presented at Canadian Wheat Symposium (CWS), November 22-25, 2016, Ottawa, Canada. See Annex 1.41.
17.	High Throughput Phenotyping of Seedling Roots in a Panel of Spring Wheat Genotypes	Khadka, K., M.N. Raizada and A. Navabi.	Poster presented at Canadian Society of Agronomy (CSA) conference, July 23-25, 2016, Montreal, Canada.
18.	Mitigating dry season food insecurity in the sub-tropics by prospecting drought tolerance nitrogen fixing weeds.	Finlay Small and MN Raizada	Presented in CSA Conference in Montreal, ON (2016). See Annex 1.42.
19.	Are women caretakers of agriculture in transition? Exploring the opportunities and challenges for food security and wellbeing in a rapidly changing agrarian area of Nepal.	Hom Gartaula and co-authors	Poster presented in Ithaca, NY; October 2015. See Annex 1.43.
20.	Encounter at the interface between community-based and school-based agro-ecological knowledge- Food illiteracy among school children in rural Nepal.	Hom Gartaula and co-authors	Paper presented in Austin, TX; February 2016. See Annex 1.44.
21.	Examining the household food security through farm diversity and dietary diversity among small farmers in post-earthquake Nepal	Rachana Devkota and co-authors	Paper presented in *International Rural Sociology Association*, Toronto, ON; August, 2016. See Annex 1.45.
22.	Is migration an antidote to	Hom Gartaula and	Paper presented in *Canadian Association for*

	underdevelopment? Examining the impacts of labour out-migration on the value system of family and family farms in Nepal	co-authors	*Refugees and Forced Migration Studies*, Winnipeg, MB; May 2016. See Annex 1.46.
23.	Forced migration and feminization of agriculture in post-earthquake Nepal	Rachana Devkota and co-authors	Paper presented in *Canadian Association for Refugees and Forced Migration Studies*, Winnipeg, MB; May 2016. See Annex 1.47.
24.	Sustainable agricultural kits (SAKs) as a strategy to scale up agriculture technologies for improving livelihoods of smallholder farmers in Nepal.	Roshan Pudasaini and co-authors	Poster presented in Global Food Security conference in Cape Town, South Africa; 03-06 December 2017. See Annex 1.48.

Social media outputs

SN	Title/topic	Media Platform	Creator	Online Links and Notes
1.	Documentary film on SAKNepal project (English full length, 20 min)	YouTube	David Borish	https://www.youtube.com/watch?v=HTt0jvG_Yws Released Dec 18, 2016 View count: 1982
2.	Documentary film on SAKNepal project (Nepali full length, 20 min)	YouTube	David Borish	https://www.youtube.com/watch?v=-GyOEdAXkYw Released Dec 18, 2016 View count: 90
3.	Documentary film on SAKNepal project (2 min movie brief	YouTube	David Borish	https://www.youtube.com/watch?v=JPfvqEZ7dvk Released Dec 18, 2016 View count: 694
4.	~20 individual SAK component 2 min videos (English and Nepali)	YouTube	David Borish	https://www.youtube.com/channel/UCrkWhLffIZVpErHNWuakYkg/videos?shelf_id=0&sort=dd&view=0 Released Dec 18, 2016 Combined view count: ~1000
5.	~100 SAK component videos and social media campaigns	YouTube Websites Social media	UGuelph undergrads	Guelph students have been creating social media campaigns for individual SAK products and practices. Ongoing: Available at: http://saknepal.org/cfa-resources/
6.	@SAK_Nepal	Twitter	Gryphon Therault-Loubier	10,600 Twitter followers as of January, 2018; with over 1040 Tweets sent about project and related matters
7.1	Canadian Youth Agrifood Trade Ambassadors (CYAFTA) – resources to promote Canadian exports and Nepalese exports	Various platforms	UGuelph undergrads	Available at: http://saknepal.org/cfa-resources/ --Canadian Youth Agri-Food Trade Ambassadors (CYAFTA - ~500 social media campaigns, including Twitter, Facebook, YouTube, Instagram, etc. to promote Nepalese agrifood exports to Canada and Cdn agrifood exports to Nepal;
7.2	CYAFTA	YouTube Channel	UGuelph undergrads	*Individual videos promoting Canadian and Nepalese agrifood companies and export ideas: https://www.youtube.com/channel/UCIPxEJqiODhxxgdms4dwgGw/videos?sort=dd&view=0&shelf_id=0 • Combined view count: approximately 16,500 as of Jan 2018.
8.	Feature radio		Guest:	Oct 1, 2016 - CBC Radio *Quirks and Quarks* with an estimated

	interview	CBC Radio	Manish Raizada Host: Bob McDonald	audience of 800,000. Interview discusses a recent discovery by the Raizada lab about finger millet, initially supported by the previous CIFSRF project. Podcast here: http://www.cbc.ca/radio/quirks/quirks-quarks-for-october-1-2016-1.3784251/powerful-microbe-fights-a-crop-fungus-1.3784303 Same as above

Major popular press outputs

SN	Press venue	Date	Audience	Topic and Links
1.	Canadian Geographic Magazine Blog	Aug 16, 2017	Canadians	"The simple agricultural kit improving life for Nepal's terrace farmers" Journalist: Brian Banks http://idrc.canadiangeographic.ca/blog/agricultural-kit-nepal-terrace-farmers.asp
2.	Ontario Grain Farmer Magazine	June 2017	Canadians	Description of SAKNepal project http://ontariograinfarmer.ca/2017/06/01/better-future-for-subsistence-farmers/
3.	University of Guelph Press Release 2017	May 31, 2017	Canadians	Innovation aids in natural disaster recovery: Journalist: Andrew Vowles https://news.uoguelph.ca/2017/05/profs-innovation-aids-natural-disaster-recovery/
4.	CBC Radio Interview	Oct 1, 2016	800,000	Noted elsewhere: CBC Radio Quirks and Quarks interview discusses a recent discovery by the Raizada lab about finger millet probiotics, initially supported by the previous CIFSRF project. Journalist: Bob McDonald Podcast here: http://www.cbc.ca/radio/quirks/quirks-quarks-for-october-1-2016-1.3784251/powerful-microbe-fights-a-crop-fungus-1.3784303
5.	Kathmandu Post (newspaper)	June 2, 2015	Nepalese	"Without urgent action, the quakes could destroy long-term livelihoods of millions of subsistence farmers" Author: Tejendra Chapagain http://kathmandupost.ekantipur.com/news/2015-06-02/save-the-soil.html
6.	Winnipeg Free Press (newspaper)	May 19, 2015	Winnipeg	"Nepal's Sherpas look to Canada for aid" Author: Kirit Patel http://www.winnipegfreepress.com/opinion/analysis/nepals-sherpas-look-to-canada-for-aid-304209301.html
7.	University of Guelph Press Release 2015	Apr 29, 2015	Canadians	From Research to Disaster Relief Journalist: Andrew Vowles https://news.uoguelph.ca/2015/04/profs-nepal-based-study-shifts-from-research-to-disaster-relief/

Outputs - Organized events for the general public and policy stakeholders

SN	Title/topic	Date	Organizer	Notes
1.	SAKNepal Film Night	May 10, 2017	David Borish	May 10, 2017 - Mayfair Theatre, Ottawa, Canada, film night to debut SAKNepal documentary film – attended by 280 people from the general public. Raised $3,000 for charities, including $1,000 for LI-BIRD farmers
2.	Canada-Nepal Agrifood Trade Workshop (Kathmandu)	Jan 2018	Roshan Pudasaini and	Organized in January 08, 2018 in Kathmandu, Nepal (Annexes 1.49.1 – 1.49.7, Annex 1.50)

			Anamolbiu	
3.	SAK Product Demonstration and Sales Events	2016-2017	LIBIRD Anamolbiu	Various events in Nepal to display and sell SAK products

Annex 3: List of 46 SAK products and practices tested in Nepal and initial test results.

SN	SAK Practices	Test results
1	Maize+Cowpea intercropping	Selected for scaling up
2	Ginger+Maize-Soyabean intercropping	Selected for scaling up
3	Maize-Bean intercropping	Dropped
4	Millet+Soyabean intercropping	Selected for scaling up
5	Millet+horsegram intercropping	Dropped
6	Millet+Blackgram intercropping	Dropped
7	Mustard+Pea intercropping	Selected for scaling up
8	Mustard+Lentil intercropping	Dropped
9	Wheat+Pea intercropping	Selected for scaling up in Dhading
10	Yam on sack as wall crop	Selected for scaling up
11	Pumpkin as wall crop	Selected for scaling up
12	Chayote as wall crop	Selected for scaling up
13	Ricebean as edge crop	Selected for scaling up
14	Horsegram as edge crop	Selected for scaling up
15	Blackgram as edge crop	Pending
16	Cowpea as edge crop	Selected for scaling up
17	Winter legumes in sequence-Lentil	Dropped
18	Winter legumes in sequence-Pea	Pending
19	Seed treatments (5 different treatments)	Dropped
20	Inverse slope	Dropped
21	Rhizobium trials	Pending
22	Biochar experiments	Dropped
23	Cattle shed and FYM improvement	Selected for scaling up
24	Drip irrigation and plastic house to grow vegetable	Selected for scaling up
25	Hybrid maize seed production	Pending
SN	**SAK Products**	**Test results**
1	Handheld corn sheller	Selected for scaling up
2	Table top corn sheller	Dropped
3	Composite vegetable seeds	Selected for scaling up
4	Jab planter (two types)	Dropped
5	Mini-tiller	Selected for scaling up with government subsidy
6	Step seeder	Dropped
7	Hand planter	Dropped
8	Farm Rake	Selected for scaling up
9	Fork weeder	Selected for scaling up
10	Electric corn sheller	Pending
11	Electric millet thresher	Selected for scaling up
12	Grain/seed storage bags	Selected for scaling up
13	Fruit pickers	Selected for scaling up
14	Magnifiers for seed sorting (glass and sheets)	Dropped
15	Labels (for local products)	Dropped
16	Hand gloves	Selected for scaling up
17	Low waist brace belt	Dropped
18	Knee and elbow pads	Dropped
19	Silpaulin plastic	Selected for scaling up
20	Maize/Pulses grinder	Pending
21	Legume seed kits	Selected for scaling up