Scaling project – Annual Report 2020

Project title: Scaling approach for flash drying of cassava starch and flour at small scale

Project start and end date: 01/01/2019 to 31/12/2020

Project leader: Thierry Tran

Project lead organization: CIAT

Partners: IITA, CIRAD

- Nigeria: TAAT, FIIRO, Open Door System, Arogunjo Farms, Hickman Ventures, Oyo Ifelodun Cassava Processing CICS LTD, Lentus Food, Deban Faith
- Democratic Republic of Congo: Agrimac, NUTRIPRO, ECOSAC, LAYUKA
- Brazil: Polvilho Orivaldo
- Dominican Republic: Angavil
- Colombia: ENSO, DERIYUCA, "Almidones Granda", "Almidones 1ª"

Country(ies) of intervention: Nigeria, Democratic Republic of Congo, Brazil, Dominican Republic, and Colombia

Total budget: 894,500 USD
NB: Total budget including indirect costs

Date of submission: January 30th of 2021

1. Progress and results

1.1. Outputs

Summarize the level of achievement of each output and briefly present the key milestones completed. Refer to the list of deliverables reported for more details (see Annex 1)

Table 1. Level of achievement of each output at end of Year 1

Output	Summarize the level of achievement
1. Clear and convincing body of data and knowledge on economic feasibility of small-scale flash drying for cassava flour or starch in Nigeria, DRC and Colombia	Plan for the flash dryer Technical and economic information was collected regarding the feasibility and viability of using the innovations in flash drying technology. This was presented in different settings in Africa and Latin America, including workshops, meetings with stakeholders, technical visits to project partners, seminars, etc. The information presented included a brief history of the flash drying technology, how to measure the efficiency of the drying equipment, and which are the main aspects to be improved in order to achieve the expected efficiency. With the financial information collected, a template was developed to analyze the financial viability of different cassava flour processing capacities (ranging from 50 to 700 kg/h). This assessment, as well as the business plans developed by the project partners, were the inputs for the development of a web-based tool. With this tool, potential users of flash dryer technology could identify the minimum flash dryer capacity in which they should invest (according to their particular context) to achieve profitable production.
2. Training material on energy-efficient small-scale flash drying	Training material: Presentation overview of small-scale efficient flash dryer development since 2014 During the main theoretical and practical workshop held at CIAT (Colombia, August 2019) with cassava flour/starch manufacturers and processors from Africa and Latin America, theoretical and technical material was used to introduce participants to the principles of design, manufacture, and modification of flash dryers. The objective was for participants to clearly understand how the innovations in flash drying technology (modifications of existing equipment or construction of new ones) would improve the efficiency of their processes, and the related economic aspects (business plans).
	Tools to calculate dimensions and operating conditions of small-scale flash dryer (based on Excel sheet) In the same workshop (CIAT, August 2019), in the practical section, calculation and design tools in Excel were used for the participants to determine the optimum length and diameter of the dryer tube, the dimensions of the feed system screw, the dimensions of the cyclone, the energy power required to heat the air in the dryer and the dimensions and design of the heat exchanger. Additionally, psychrometric charts were used to get a general idea of the efficiency of the drying process.

Output	Summarize the level of achievement
	Tool to calculate business plan for investment in a small-scale flash dryer One of the main challenges for processors of cassava flour/starch is to mobilize the investment needed to adopt the improved technology. The costs of manufacturing and installing a flash dryer, and of the complementary technologies (rasper and press), can amount to 40,000 to 50,000 USD, depending on the capacity of the equipment and the country where it is manufactured. Some processors may be able to obtain such financing through bank loans (or other types of financing). For this reason, at the efficient flash dryer workshop held in August 2019 at CIAT (Colombia), a theoretical-practical section was worked on with the processors to develop the capacity to prepare a business plan that will allow them to evaluate the viability of the investment, as well as show the financing institutions the projections of production expenses, market and price dynamics, cash flow and financial balances.
	Surveys of the technical expertise of the equipment manufacturers in DRC and Nigeria Surveys were conducted to determine the experience and technical expertise of the partners prior to the start of the Scaling Readiness Flash Dryer project. Equipment manufacturers reported whether they had previously manufactured flash dryers and/or technological components complementary to cassava flour drying. They also reported on the availability of materials and tools needed in the manufacture of good quality equipment. On the other hand, processors were asked what previous experience they had in processing cassava roots, whether they had flash dryers, and what were the main technical issues in their processing systems. They were also asked about socio-economic aspects such as the availability of roots in their locality, the behavior of the cassava flour/starch market, among others. Afterwards, technical visits were made to some of the project partners. These visits made it possible to validate the information collected. These visits also provided an in-depth understanding of the operation and bottlenecks in their processing (and manufacturing) systems. During these visits, the team of researchers from CIAT and CIRAD saw first-hand the needs of the production plants in Colombia, DRC and Nigeria. In the first visit in July 2019, African processors currently operating a flash dryer were given recommendations on potential improvements identified: heat exchanger, feed system, drying tube size and pressing. By the second visit in November 2019, some processors (especially in DRC) had made some recommended modifications, which represented improvements in process efficiency. The LAYUKA processor, for example, modified the heat exchanger by inverting the flow of fresh air against the hot air and managed to reduce from 3 to 2 litres of diesel for each 20 kg bag of dry flour. On the other hand, NutriPro improved the heat exchanger after the Cali training. That contributed in reduction of the fuel consumption by 30 %.

Output	Summarize the level of achievement
	Technical support activities Technical support activities have been carried out through two mechanisms: face-to-face and virtually. The CIAT-CIRAD team made two visits during 2019. Scaling Champions in each country made periodic visits during the course of the project. During these visits, the main issues in flour processing were identified, the efficiency of the drying equipment was measured, and cassava flour samples were taken to verify its quality. In addition, specific instructions were given for the construction of new dryers as well as for the ongoing modifications of the old flash dryers. Similarly, project partners were trained in the mechanisms for controlling flour quality, methodologies for quality control of the drying process, manufacturing techniques, among others. According to a survey of project partners, the only text messaging application that 100% of respondents have access to is WhatsApp. For this reason, the use of this platform was tested as an alternative to providing technical support to equipment manufacturers and cassava flour processors. Through this resource, design ideas for heat exchangers, burners, and particular aspects of the feed system have been shared. In addition, this chat group addressed specific concerns about component dimensions and manufacturing techniques. Due to the COVID-19 pandemic, in 2020 it was not possible to make face-to-face technical visits. Therefore, during this period of time, other platforms such as Skype, Meet, Zoom were useful for periodic virtual meetings. Through these meetings, doubts were clarified and the progress of the construction and modification of flash dryers, heat exchangers, as well as other components of the drying system were followed up.
	Interviews to the participants during the training sessions. A video was prepared with interviews with participants from Africa and Latin America. The objective of the video was to consult what their expectations were about the flash drying workshop, held at CIAT, Cali, in August 2019. They were also asked about the potential use of flash drying technology in their country and the main challenges they face. The video can be viewed/downloaded at the following link: https://youtu.be/FpeM1zdwoSs
3. Handbook of quality standards for flash-dried cassava	Handbook of quality standards for flash-dried A manual was prepared for quality control in cassava flour processing and another for cassava starch quality. An infographic design was used, with the purpose of having a synthetic template that will be easier to consult and share through social networks. It is expected that this type of manual will be useful not only for project

Output	Summarize the level of achievement
starch and flour, including methods of assessment	partners, but also for other stakeholders in the cassava starch and flour value chain in each country. This manual included the quality parameters of the resulting product at each stage of cassava flour processing and the respective analysis methodologies. For starch, the main quality indicators were presented. The techniques, methodologies, equipment and instruments used for each parameter were also specified in detail.
4. Business plans and models for investment in flash drying according to three to four scenarios taking into account: construction of new dryer or modification of existing dryer; adaptation of dryers for different production capacities; types of energy and quantities of cassava locally available	Business plans calculation tool (Excel) The template that was prepared for the theoretical-practical section of the business plan worked on with the project partners in the flash drying workshop held at CIAT-Cali, includes the following aspects - Calculation of the investment required for the manufacture or modification of flash dryers - Estimate of investment sources (own resources, bank credits, investors, others) and projection of time of use and return of capital - In this regard, other considerations should be taken into account such as: bank credit amortization times, interest on the acquired credit, depreciation of the drying equipment to be acquired, among others. - Estimate and projection of production costs related to payment to suppliers, raw materials, transportation, fuel, utilities (electricity, water, gas), labor, leases, packaging, taxes, others. - Projection of cassava flour sales. - Cash flow assessment, balance sheets and financial analysis of the investment and economic activities of the company The cassava flour/starch processors carried out the exercise of developing their own business plan. These documents were received, and analyzed with the purpose of identifying possible weaknesses in the formulation, and to make respective recommendations on their projections thus improving their financial indicators (These analyses and recommendations are summarized in the business plan analysis report). These plans could become a good navigation tool for their businesses, and a possible way to present projections to investors and/or banks to acquire the necessary resources for the manufacture and/or modification of flash dryers.
5. Organizational models for creating enabling	Documentation of the management of initiatives as Organizational models In order to create the conditions for the adoption of flash drying technology, several initiatives were carried out, which we will summarize by country or region:

Output	Summarize the level of achievement
conditions for adoption of small-scale flash drying technology at factory level and value chain level (cassava producers, institutional environment, access to capital, etc.)	**COLOMBIA:** We participated in the formulation of a project led by the University of the Cauca (UNICAUCA, South-West Colombia), and financed by the Colombian State (COLCIENCIAS). The project aims to promote the use of technologies for the production of bio-plastics from cassava starch, which include the use of flash drying technology to produce cassava starch. We contributed to the preparation of an investment plan and feasibility analysis with La Salle University (Casanare department, East Colombia) for the use of flash drying technology within an agro-industrial model integrating staggered cassava production, flour extraction (and drying using a flash dryer), formulation of animal feed supplements, animal husbandry and marketing of livestock and other minor species. The flash drying technology was found to be viable taking into account the planned production capacity, and the technical and logistical conditions of the Mataepantano campus where La Salle University is based. However, due to the pandemic, UNISALLE was unable to raise the investment for the flash dryer, this could be a good opportunity to promote the use of flash drying technology. Given that this institution is an academic, research and rural extension centre, its objective is to promote this integrating productive model in East Colombia (Llanos) region, which has the potential for agricultural exploitation and the linking of technologies for the transformation of raw materials to generate value in the productive chains. **DOMINICAN REPUBLIC:** The company ANGAVIL**,** dedicated to the transformation of cassava and export to USA of products like *Casave,* has been interested in acquiring a flash dryer to incorporate cassava flour as a new line of products. To this end, analyses have been carried out to determine the feasibility and viability of the project to acquire a flash dryer, taking into account market demand. **NIGERIA**: The *Scaling Flash Dryer* Project was presented at the TAAT Cassava Investment Forum meeting in Abuja, 18-19 July 2019. During this workshop, participants were introduced to the scope and objectives of the *Scaling Flash Drying project.* The event was attended by flour and starch processors, government representatives, bankers, cassava producers, among others. In November 2019, a meeting was held with interested parties among whom were invited: researchers, representatives of the Ministry of Agriculture, representatives of the Ministry of Industry and Scientific Research, representatives of international organizations, banks, equipment manufacturers, cassava processors, and cassava producers and processors associations (See program in Annex). **DEMOCRATIC REPUBLIC OF CONGO**: As in Nigeria, a meeting was held in December 2019 with stakeholders of cassava to inform about the Scaling Flash drying project. Some media were present and publicized the event. The press releases about the event can be seen at the following links:

Output	Summarize the level of achievement
	https://zoom-eco.net/a-la-une/rdc-iita-presente-cassava-flash-dryer-un-sechoir-a-haut-rendement-energetique-economique/ http://mobile.topcongo.fm/article/le-sechoir-flash-technologie-pour-une-transformation-de-qualite-de-la-farine-de-manioc-en-rdc-iita-5311 https://www.lephareonline.net/liita-sensibilise-sur-lusage-du-sechoir-artificiel/
6. Geo-referenced equipment manufacturers, cassava processors and cassava producers at country level and regional level	Maps of DR Congo, Nigeria, Colombia and Excel database with the geo-referenced equipment manufacturers and cassava processors A database was created with the georeferenced points of the cassava processors and equipment manufacturers linked to the project. These points were reported on maps of Nigeria, DRC and Colombia. The GPS location of the value chain actors who were most involved in the development of the Scaling Readiness-Flash Dryer project was collected. With this data, a map was created using the Google maps application. This map provides details of each actor in the value chain such as the name of the association or company, name and contact telephone number (in the case of those who agreed to share the information). The Google Maps application allows to observe the nodes that are formed between actors in each specific location. It also offers the possibility to measure the distances between a cassava producer and his customer. Respectively, the time and distances traveled between flour processing plants and their buyers can be estimated. The map is available on the website: -For Nigeria´s Cassava flour value chain https://www.google.com/maps/d/viewer?mid=1CyaoEcXCxDMz8oTn1v1DYDVuet8nJXQq&hl=es-419&usp=sharing -For DRC´s Cassava flour value chain https://www.google.com/maps/d/u/0/edit?mid=1KXMps0my246WzrwDR5_yHxpJHfZo_C7R&usp=sharing
7. Scaling readiness approach documented	Intervention profile has been completed and is documented
	Innovation profile has been completed and is documented
	Stakeholder profile has been completed and is documented
	Diagnosis survey has been completed with at least 30 stakeholders and analysis of the results is documented including at least 80% of the key innovation components identified in the surveys
	Innovation package described with core and complementary components clearly identified

Output	Summarize the level of achievement
	Theory of scaling workshop has been conducted with a number of stakeholders that is representative of the diversity identified in the stakeholder profiles and is documented
	Theory of scaling document produced using the suggested format
	6-month reflection and learning reports produced and adjustment in plan of work and/or scaling strategy documented
	Scaling readiness vs. Innovation use assessment

1.2. Outcomes

Present a quantitative assessment of the results achieved and explain any difference with the expected targets. Refer to the project proposal for the complete list of research and development outcomes.

Table 2. Quantitative assessment of the results achieved based on research and development outcomes

Development outcomes	Results Achieved
1. At least 6 cassava processors invest in flash dryers (build or refurbish), and increase by 25 to 50% their production of cassava starch or flour	Indicator: % increase of (i) Production: During the project period, 8 cassava processors invested in flash drying innovations, as follows: -**DRC**: -NUTRIPRO: (a) In early 2019 invested in a flash dryer and increased production capacity by 50% compared to solar drying. b) In late 2019, modified the feed system, and heat exchanger, added an electronic temperature controller to its processing system. c) In 2020, invested in a new, more efficient heat exchanger design, which achieved a 30% reduction in diesel consumption. LAYUKA: (a) In 2019 made modifications to its heat exchanger. Achieved a 33% reduction in fuel consumption. b) During 2020, started construction of a new heat exchanger. At the time of writing this report, the manufacturing of the equipment has not been finalized, therefore there is no information available on its efficiency. FERME MAKOBI a) In 2019 participated in a meeting of cassava flour value chain stakeholders in Kinshasa, decides to invest in the flash dryer.

b) In 2020 invests in the flash dryer. At the time of writing this report, the manufacturing of the equipment has been completed but it has not been installed. Therefore there is no information available on its efficiency.

FERME BIBWA

a) In 2020 invest in the flash dryer. At the time of writing this report, the manufacturing of the equipment has not been completed. Therefore there is no information available on its efficiency.

ECOSAC

a) In 2020 invest in the flash dryer. At the time of writing this report, the manufacturing of the equipment has not been completed. Therefore there is no information available on its efficiency.

-Nigeria
LENTUS FOOD

a) In 2020 invests in a heat exchanger. At the time of writing this report, the manufacturing of the equipment has been completed however it has not been installed. Therefore there is no information available on its efficiency.

OKUNBOH FOODS LIMITED

a) In 2020 this processor purchased the flash dryer that manufacturer Hickman Ventures initially built for Goldbridge Foods Limited, but sold it because, according to the processor, the flash drying technology "did not fit into the production logistics used for yam flour". At the time of writing this report, the processor Okunboh Foods Limited was making changes to its company's infrastructure in order to install the flash dryer. Therefore, there is no information available on its efficiency.

-Colombia

UNICAUCA

a) In 2020 starts manufacturing a flash dryer for the processing of cassava starch. At the time of writing this report, construction has not yet been completed.

	(ii) Profit generated per ton of product sold: (average and disaggregated by individual processor) As shown in Table 3, the average net profitability (before taxes) per ton of cassava flour is $188 USD in Nigeria and $239 USD in DRC. Detailed records are only available for two plants. Data from LAYUKA (DRC), where the heat exchanger was modified according to the suggestions received in the project, shows a 33% reduction in fuel and a corresponding increase in net profitability per ton of flour produced of 8%. In the case of NUTRIPRO (DRC) in 2019 they invested in the manufacture of a flash dryer, to replace the solar dryer. This implies a higher productivity (from 10 to 15 tons of flour/month), higher efficiency in the drying and final quality of the product, the net profitability increased by 10%.
2. At least 12 equipment manufacturers and cassava processors organized in a support network to exchange information on flash drying technology, using social media (e.g. Whatsapp)	I: Number of contributors in the online support network. As part of the technical support activities, a group was created on the text message platform Whatsapp, to which 42 participants are linked, of which -5 are equipment manufacturers (2 from Nigeria, 2 from Colombia and 1 from DRC) -13 cassava flour processors (5 from Nigeria, 3 from DRC, 1 from Dominican Republic, 1 from Brazil and 1 from Colombia, 1 from Uganda. -2 cassava producers -Other participants: Scaling Champions and monitor, researchers/technical support team, project coordinators, other guests Since its creation in August 2019, during the flash drying workshop held at CIAT Colombia, technical specifications on the design and manufacture of drying components such as the heat exchanger, feeding system, etc. have been shared frequently.
3. In the 3 selected countries, value chain stakeholders (local government, private sector) coordinate their actions to facilitate the integration of flash drying technology in existing value chains	I: Number of ongoing public or private sector initiatives targeting better integration of flash drying technology in existing value chains (e.g. projects, credit schemes, trainings) that have been informed and/or influenced by project results. **Nigeria- 2 initiatives:** 1) Participation in the TAAT- forum (July 2019). 2) Meeting with stakeholders (cassava producers, bankers, cassava processors, members of associations and institutions promoting the production of processing and development of the cassava industry, others (November 2019) **Democratic Republic of the Congo- 1 initiative:** Meeting with stakeholders (local and national government representatives, international bodies such as the UN, traders, media, bankers, cassava processors, members of associations and institutions promoting the production of cassava processing and development, others (December 2019). **Colombia- 2 initiatives**

	1) Participation in the formulation of a promotion and development project led by the University of Cauca, aimed at producing bioplastics from cassava starch. The process line must incorporate flash drying technology. 2) We participated in the formulation of a productive and extension project led by the University of La Salle, which has as its objective the production and transformation of cassava into flour for the preparation of food supplements for livestock and minor species. The project will use flash drying technology.

Research outcomes	**Assumptions/Risks & Indicators**
1. At least 8 equipment manufacturers and cassava processors with strengthened knowledge and skills in the construction, operation and maintenance of small-scale flash dryers	I: Number of trainees that are applying improved practices in construction, operation and maintenance of small-scale flash dryers. by the end of 2020, 4 manufacturers (3 from Nigeria and 1 from DRC) and 7 processors (1 from Colombia, 1 from Nigeria and 5 from DRC) applied the knowledge for the manufacture, modification and operation of flash dryers.
2. At least 6 scaling partners (i.e. potential investors, cassava processors, equipment manufacturers) developed a business plan for investing and operating flash dryers using information and models provided by the project.	I: Number of scaling partners who produce a bankable business plan proposal. Three (3) DRC processors, one (1) from Nigeria and (1) from the Dominican Republic developed a potentially fundable business plan proposal. The plan developed included the costs of production or modification of the flash dryer and/or complementary innovations. Additionally, a projection of the profitability of cassava flour production was included, in the following 5 years. This planning took into account variations in production costs, investment amortization, equipment depreciation, and other considerations. The template used presented a summary analysis of the cash flow and balance sheets of the operations and financial indicators that could serve as tools for the presentation of the investment project to bankers.
3. In each country, at least one consultative process to design enabling initiatives for the introduction of flash drying technology in the value chain has been led or co-led by national stakeholders (local government, farmers, SMEs).	I: Number of consultative processes organized in each country (e.g. interviews, focus groups, role-playing simulations, etc.). One consultative process in Nigeria and one in DR Congo: In November 2019, a meeting was held in Nigeria (hosted by FIIRO, Lagos) and DR Congo (hosted by IITA, Kinshasa) with stakeholders whom were invited: researchers, representatives of the Ministry of Agriculture, representatives of the Ministry of Industry and Scientific Research, representatives of international organizations (e.g. UNIDO), banks, equipment manufacturers, cassava processors, and cassava producers and processors associations. After presenting the objectives and scope of the scaling project, focus groups were held in order to elicit information on the main barriers to the development of the cassava flour value chain in these African countries. These meetings made it possible to confront different critical views on the

	problems and to address possible collective and multi-sectoral strategies.
4. In at least one country, value chain stakeholders used geo-referenced map on cassava value chain stakeholders to inform and design coordinated actions.	I: Number of consultative processes organized in each country, that used geo-referenced maps to inform planning and decision-making. Since 2019, the TAAT project developed a open database where it included numerous stakeholders in the cassava value chain in Nigeria. Although there is no evidence that this geo-referencing has been used by any processor/producer interested in upgrading or buying a flash dryer. It may help to link our dryer manufacturing partners with processors interested in investing in these innovations.

To present the quantitative analysis of development outcome No. 1, the production averages and increases for the processors in Nigeria and DRC were outlined in Table 3. Similarly, the respective processing costs, net profit (before taxes) and the increase in profitability generated by the interventions of the current Scaling project are summarized in Table 2.

Table 3. Production average and net profit increase for Flash Dryer adoption or improvements in factories of Nigeria and DRC during 2019.

Country	Factory	Before Ton/month	Current Ton/month	% increase production	Cost for process 1 ton	Flour Sell price (1 ton)	Net profit (before taxes) (per ton-flour)	% increase in profitability (per ton-flour)
Nigeria	Open Door System	4	4	0%	$ 215	$ 429	$ 214	0%
	Lentus Foods	36	36	0%	$ 237	$ 444	$ 207	0%
	Arogunjo Mills Limited	24	24	0%	$ 339	$ 414	$ 76	0%
	Ifelodun	3	3	0%	$ 228	$ 430	$ 202	0%
	EIRrasheed farm limited	15	15	0%	$ 116	$ 359	$ 243	0%
AVERAGE		**16**	**16**	**0%**	**$ 227**	**$ 415**	**$ 188**	**0%**
DRC	Nutripro	10	15	50%	$ 812	$ 1.100	$ 288	10%
	Layuka	6,5	8	23%	$ 680	$ 937	$ 257	8%
	Ecosac	13	13	0%	$ 827	$ 1.000	$ 173	0%
AVERAGE		**10**	**12**	**24%**	**$ 773**	**$ 1.012**	**$ 239**	**6%**

Indicate what was the project contribution in institutionalizing capacities to foster the scaling process (what organizations/groups are capable of taking this forward beyond the scaling project – in terms of knowledge, interest, and means to do so; with some supporting evidence for claiming this).

The project has had the active participation of the institutions: International Institute of Tropical Agriculture (IITA), Federal Institute of Industrial Research, Oshodi (FIIRO), Federal University Ndufu-Alike (AE-FUNAI), in Africa; and the University of Cauca in Colombia. These institutions are leading projects and initiatives that will promote the use of flash drying technology, even after the Scaling project is over.

Other key promoters of the technology are the equipment manufacturers. They quickly adopted the principles of flash dryer design and manufacture, understanding that they were indispensable for selling efficient drying technologies. The manufacturer partners of the Scaling project have applied these innovations in their recent work contracted by private processors and institutions that, in some cases, are not associated with the Scaling project. An example of this was the flash

dryer built by Hickman Ventures, for Goldbridge Foods Limited in Nigeria in October-November 2019 (See figure 1). This dryer is derived from the design of the prototype installed at CIAT-Cali, that was presented during the workshop on flash drying technology in August 2019.

Figure 1. New Flash dryer, installed in Goldbridge Foods Limited, Nigeria, by the fabricator Hickman Ventures.

A second example is the collaboration between Agrimac, an equipment manufacturer in DRC, and Nutripro, a cassava processor, to build a flash dryer adapted to the economic context of cassava flour production in the region of Kisnhasa (this flash dryer is under testing at time of reporting). Agrimac was also contracted in 2020 by TAAT to design and install a flash dryer in the IITA facilities in Eastern Congo. This dryer will be used as part of TAAT Cassava Compact production project, as well as a model to encourage the use of flash drying technology among cassava processors in that region. The flash dryers being built by Agrimac incorporate several innovations introduced by the RTB activities on flash drying, including in particular longer drying tube and redesigned heat exchanger. In Eastern Congo, at the opening event of the project organized by IITA, the president of Nigeria was invited to see how well the Agrimac flash dryer works, which led to the award of a contract to supply a flash dryer to TAAT.

Present other effects (positive or negative) that were not foreseen beforehand (e.g. new partnerships which came into existence that also have a positive contribution to other things than scaling that particular innovation; changes in the policy environment that show increased government interest in particular crops, integrated agricultural/livelihood approaches, etc.; unexpected negative environmental trade-offs of intensification practices; unexpected social or gender-related biases related with components of the innovation package or scaling strategy).

Within the framework of the Scaling project in Nigeria, a survey of 41 cassava processors in Kwara, Lagos, Ogun, Osun and Oyo States was carried out in Nigeria. Of which 49 % of the flash dryers are currently not in use (Figure 2). The main reason why this number of dryers are not operating, (and most of those that are operating, do so occasionally), is because the market is not adapted for small-scale processors. There is currently a demand for cassava flour from large companies such as Nestlé, which require about 30 to 60 tons per week. These producers generally have the capacity to produce about 6 tons per week. And the problem of associating several producers to meet the quota demanded by the market is that they do not achieve homogeneity of quality in the final product. This became the main bottleneck in this country, even on top of the energy inefficiency of previous models of flash dryers.

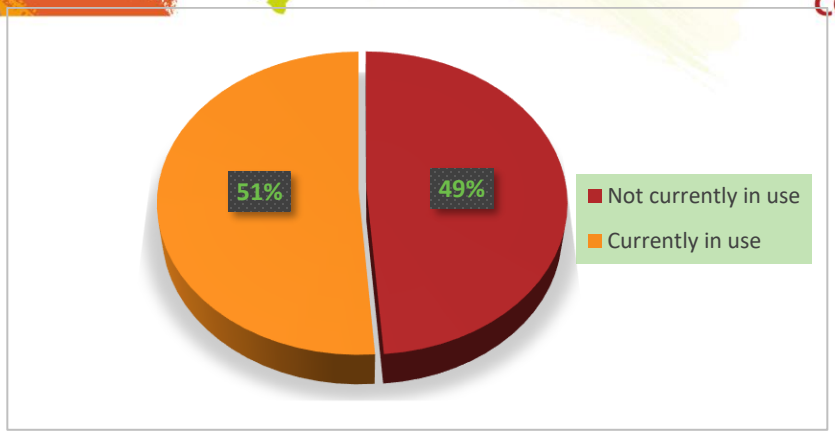


Figure 2. Nigerian processors who are still using a flash dryer vs not using

It was found that the government is aware of this situation and has launched initiatives to stimulate the cassava flour market. For example, since 2004, the incorporation of high quality cassava flour into flours for human consumption is being stimulated, in 2015 the mandatory participation quota reached 10% and according to the new bill of 2019, it will be mandatory to reach 20% of cassava flour. These measures represent an opportunity to energize the market with quality products, and a need to acquire efficient technology for the economic sustainability of cassava production.

In Colombia, the initiative to promote the production of bio-plastics from cassava starch, led by the University of Cauca, was discovered. With this initiative the opportunity arose to make a synergy with the Scaling Flash Dryer project, because solar drying, (as starch is usually dried in the Cauca Colombia region) is not suitable for this purpose, due to the impurities incorporated into the starch during this process, which compromises the final quality of the bio-plastic. Later, it was discovered that the starch extraction technology currently used by the graters is not viable for this purpose either, since the resulting starch has traces of other biological materials from the cassava such as lignins, pectins, celluloses, among others, which also prevents having a suitable starch to transform it into a quality bio-plastic. As a result, it is suggested to adopt Chinese starch extraction technology with the use of hydro-cyclones and the manufacture of a flash dryer with the same manufacturer, in order to assemble the whole assembly.

1.3. Impact

Present a qualitative and, as far as possible, quantitative assessment of the contributions toward the expected impact (e.g. indications that achieved outcomes contributed and will contribute to changes in livelihood, food and nutrition security, business opportunities, resilience to climate shocks, sustainable management of resources) and explain any difference with the expected targets. Refer to the project proposal for the initial impact statement.

Table 4. Qualitative and quantitative assessment of the contributions toward the expected impact

Initial impact statement.	Qualitative impacts	Quantitative impacts
10 to 12 cassava flour and starch factories increase	These increases in production capacity generate greater income for	During 2019 and 2020, three processors made upgrades to their flash drying and

Initial impact statement.	Qualitative impacts	Quantitative impacts
their processing capacity by at least 25 to 50% by 2022	the company by increasing profitability, which impacts the quality of life of families working in the company, will also generate greater job opportunities.	complementary equipment. This meant an average increase in processing capacity of 36%. On the other hand, 7 cassava processors invested in new next-generation flash dryers. In some cases, their capacity increased 100% because they were not processing cassava previously. Others used solar drying, which represented an average increase of 30% in their processing capacity, others had a flash dryer with low energy efficiency and/or low capacity (e.g. OKUNBOH FOODS LIMITED which had a 20 kg/h dryer and acquired a 300 kg/h capacity dryer). Although we still do not have enough information to estimate the increase in capacity of these processors, we estimate that it was significantly higher.
Additional demand for cassava roots reaches 10.000 t roots/year by 2022.	With the technological improvements and consequent increase in the efficiency of cassava processing, the business will become more sustainable from an economic point of view. This will positively impact the value chain by increasing the demand for roots, which will encourage their production, benefiting local cassava producers.	If the 7 new flash dryers that were scaled up in the present project were to operate at their maximum capacity (300 kg /h, for 8 hours/day, 5 days/week and 48 weeks/year), this would imply that approximately 4000 tons of cassava flour/year would be processed. This would require an additional demand of 16000 tons of roots/year. However, a realistic estimate (based on current information of the cassava value chain) makes us think that the new flash

Initial impact statement.	Qualitative impacts	Quantitative impacts
		dryers built in Colombia, Nigeria and DRC could operate at 50% of their total annual capacity.
Additional income generated reaches 400 000 USD/year by 2022, distributed among 660 cassava farming households (600 USD/year/household).	An increase in the profitability of cassava flour/starch processing will improve the quality of life of the families of producers and root processors because they will receive higher incomes from a growing and sustained demand for roots.	A conservative estimate (described above) of an additional demand of 8,000 tons root/year, could generate an additional income of 320.000 USD/year by 2022, distributed among 660 cassava farming households (480 USD/year/household). On the other hand, the two processors (2) that adopted innovations in their drying systems, managed to increase profitability by 8% and 10% respectively. This implies an increase in income for these two producers of about $10,000 USD by 2020.

2. Documentation and reflections on scaling and Scaling Readiness

Under this section we would like to capture (1) some strategic and key outputs of the scaling strategy development, implementation and monitoring using Scaling Readiness, and (2) reflections on the use of Scaling Readiness as a roadmap for more impactful scaling of RTB innovation. We will follow the logic of the 5 Steps of Scaling Readiness.
More detailed compliance with the Scaling Readiness implementation is captured through the compliance matrix.

2.1. Step 1: Characterization

Innovation package

2.1.1. Describe the innovation package as defined in the project proposal.

In the Flash Dryer case study, one innovation package was defined, including a total of 18 core and/or complementary innovations (Table 5). The innovations were classified under different innovation types including products, services, practices, and institutional arrangements. Each innovation is described, and its geographical relevance is specified, given that some of these innovations only apply to one, two or three of the countries involved in the Flash Dryer project.

Table 5. Description of the country-specific innovation packages for the Flash Dryer.

Type of innovation	Innovations	Description	Geographical relevance		
			Nigeria	DR Congo	Colombia
Product	Efficient Flash Dryer	Design of flash dryer developed by the RTB research program can reduce drying costs by two to three compared to current small-scale designs.	x	x	x
	Feed system improved	Innovation in the starch / flour feed system to the dryer, that improves the homogeneity (particle size) of the supply.	x	x	x
	Dewatering improved	Technological proposal of mechanical pretreatment of the raw material to reach +/- 35% humidity prior flash drying. Options considered are press and/or centrifuge to remove water.	x	x	x
	Hot air generator improved	Designs adapted to the requirements and particular conditions of each country to optimize energy consumption and production costs. Depends on type of fuel available (e.g. diesel, gas, agricultural residues/biomass, etc.) and type of burner technology and heat exchanger technology available.	x	x	x
	Fans/ blowers	Current flash dryers do not achieve sufficient air velocity and flow rate, which limits production capacity.	x	x	
Service	Improve perception of cassava flour	Marketing promotion of the use of cassava flour for industrial processes and food applications. Current perception is that cassava flour is of low quality (e.g. dust		x	

		contamination due to sun drying). The flash drying innovation has potential to solve this issue.			
	Market promotion for Small scale cassava flour	(i) in Nigeria demand for cassava flour (HQCF) is typically by trailer (30 tons per order), which is too high for the production capacity of small-scale processors (1 ton/day), and (ii) in the Dominican Republic there is increasing demand for gluten-free flours, including cassava flour.	x		x
	Capacity Building on flash drying technology	Organize a workshop (CIAT, Colombia) for theoretical and practical training on flash drying, including training on the prototype flash dryer and training in auxiliary technologies (dewatering, hot air generation, feed system, cyclone, etc.).	x	x	x
	Capacity Building - Business plans	Organize a workshop (CIAT, Colombia) on the economic aspects of investment in a flash dryer: Estimation of costs of investment and operations; estimation of revenues generated; business plans.	x	x	x
	Training	Follow-up of the workshop at CIAT: To provide additional training as needed in each country of the project. Topics: Business plans; design, construction, adaptation of flash drying technology to local conditions and constraints.	x	x	x
	Innovation forum	Benefits of flash drying, Financial aspects. Objective is to bring together and promote multi-stakeholders dialogue between entrepreneurs, processors, eqpt manufacturers, funders, government agencies (etc.).	x		

	Inventory of ongoing projects on cassava processing	Achieve potential synergies with other projects.	x	x	x
	Access to capital or loans	Information from banks about the conditions and information to provide to access investments loans.	x	x	x
	Continuous technical support	Technical forum through facilitated WhatsApp group (English), and technical support through visits to construction sites.	x	x	x
Practice	Test expansion quality	Adaptation of drying technology to the production of sour cassava starch, by testing the expansion quality of flash dried sour starch compared to sun-dried.			x
	Feasibility of investment projects	Availability of raw material & energy at acceptable cost in the target locations for a cassava starch/flour factory.	x	x	x
Institutional Arrange-ments	Cooperatives formation	Assess the feasibility of establishing cooperatives of cassava producers (possible support by central bank loans) to ensure sufficient supply of cassava roots to the proposed starch or flour factories.	x	x	x
	Contracts	Contract between processors, equipment manufacturers and project teams in order to define the responsibilities, commitments (financial and otherwise) and expected benefits of all parties.	x	x	x

2.1.2. Explain which were the main changes that have been made in the innovation package and the reasons/ processes that have determined these changes.

Two complementary innovation components were added:

-Access to **the market** (type: *Service;* Outreach: Nigeria, Colombia, Dominican Republic): after applying surveys to project partners and stakeholders, we identified that (i) in Nigeria demand for cassava flour (HQCF) is typically by trailer (30 tons per order), which is too high for the production capacity of small-scale processors (1 ton/day), and (ii) in the Dominican Republic there is increasing demand for *gluten-free* flours, including cassava flour. To meet the initial objective of supporting the establishment of flash dryers under commercial operation, introducing this additional innovation component "Access to market" is important to further understand market demands and determine the best strategies for flash drying technology to contribute to economically viable production of cassava flour.

-Flash dryer fans/blowers (type: *product; Scope: Nigeria and DRC*): Technical visits and performance measurements of flash dryers currently in operation for the project partners revealed that fans equipping current flash dryers do not achieve sufficient air velocity and flow rate, which limits production capacity. Hence the decision to add this innovation component on improving fans for flash dryers.

2.1.3. Explain whether and how the innovation package's core and complementary innovations were (re) defined

The Scaling readiness framework was central to identify the importance of the two complementary innovations (Access to market and Flash dryer fans/blowers) discussed above, and to the decision to include them in the innovation package.

During the first year of the project, we assessed the level of use and readiness of each innovation component by different stakeholders in the cassava flour/starch value chain, through the application of ad-hoc surveys.

While most innovation components were at suitable levels of use and readiness, a key bottleneck for flash drying to be adopted in Nigeria and Colombia was that the market demand for cassava flour or starch is not adequate for small-scale processors to participate, due to limited production capacity. This is one contributing factor to why flash drying technology is not yet widely used commercially in Nigeria and Colombia, and underlined the need to better analyze market structure. This need is now reflected with the addition of the complementary innovation Access to market.

In Nigeria and DRC, the level of use of fan/blower technology is high, because among the cassava flour processors that have flash dryers, all have a fan, a necessary component of flash dryers. On the other hand, the level of readiness of fans was low in both countries, because

in most cases the power of the fans was too low to achieve adequate air velocity, resulting in low production capacity. Some equipment manufacturers acknowledged that they did not have enough experience to build larger fans (due to balancing issues with the rotor) and that they did not know the methodology to determine the efficiency of the fan (e.g. air velocity). To address this need, we added the complementary innovation Flash dryer fans/blowers to the innovation package. This is part of the complementary innovations aiming at improving the technical design and efficiency of small-scale flash dryers.

2.1.4. Explain whether and how the innovation package was updated/ tailored for the different locations where the Scaling Fund project has activities

Two new innovation components were added to the innovation package, with differences between locations:

(1) Access to market: We identified key differences between Nigeria and DR Congo, which translate into different level of readiness and level of use on the Scaling readiness diagram (figures 3 and 4) in both countries. **Nigeria:** HQCF is not an everyday consumption product, and buyers are large companies (Dangote, Nestlé, flour millers, …) with minimum order 30 t (one trailer). Such orders are difficult to fulfil with the current production capacity of SME cassava processors (1 ton of flour/day); i.e. mismatch between production capacity and demand. **DRC:** Cassava flour is an everyday consumption product with several small retailers buying 500 to 1500 kg/week. The production capacity of SME cassava processors including production capacity of current flash dryers is well matched with demand, so that cassava processors have no difficulty accessing the market. Demand for flash dried cassava flour is also increasing thanks to better quality than sun-dried cassava flour (less contamination by dusts and less off-flavors when sun-drying took too long due to meteorological conditions).

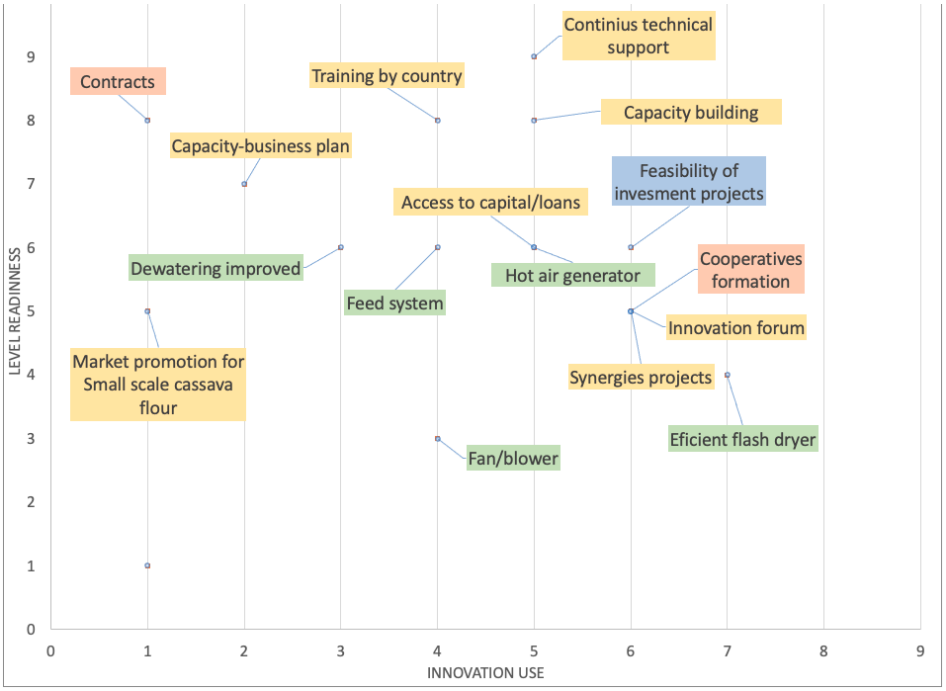


Figure 3. Scaling readiness diagram showing the innovation package for Nigeria

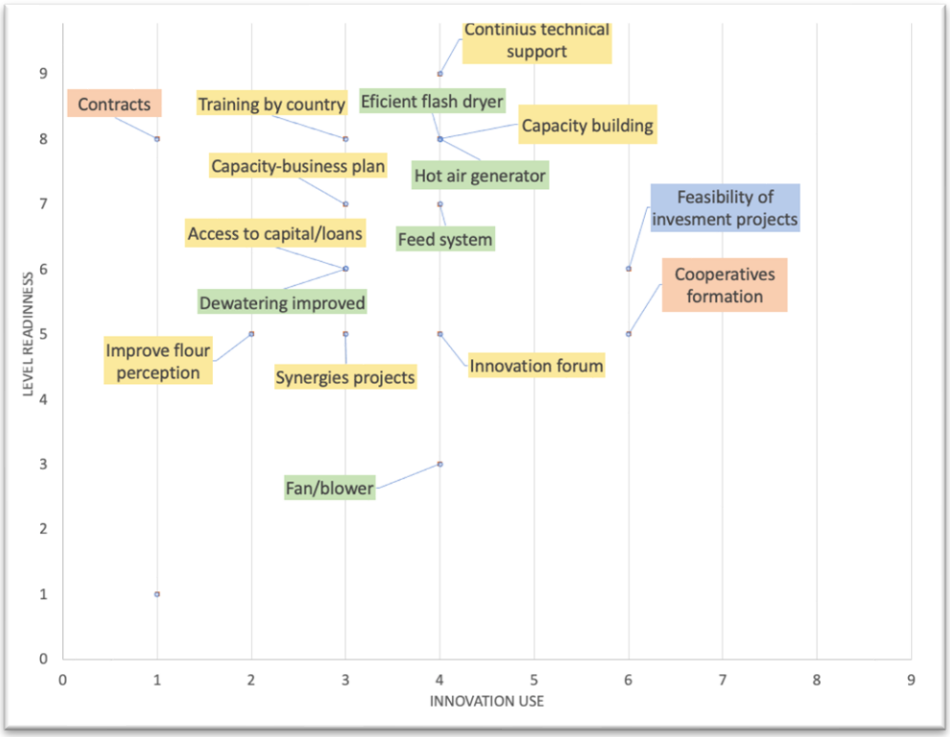


Figure 4. Scaling readiness diagram showing the innovation package for DR Congo

In **Latin America,** it was also necessary to analyze market access for cassava flour in Colombia and the Dominican Republic. With the **Universidad de la Salle** (in Colombia), a partner in the Scaling project, the project team analyzed the technical and financial viability of using flash drying and the potential market for cassava flour for animal feed in the east of the country. The company **ANGAVIL** (Dominican Republic), partner of the Scaling project, during the past two years has been planning the installation of a cassava flour processing line using flash drying technology.

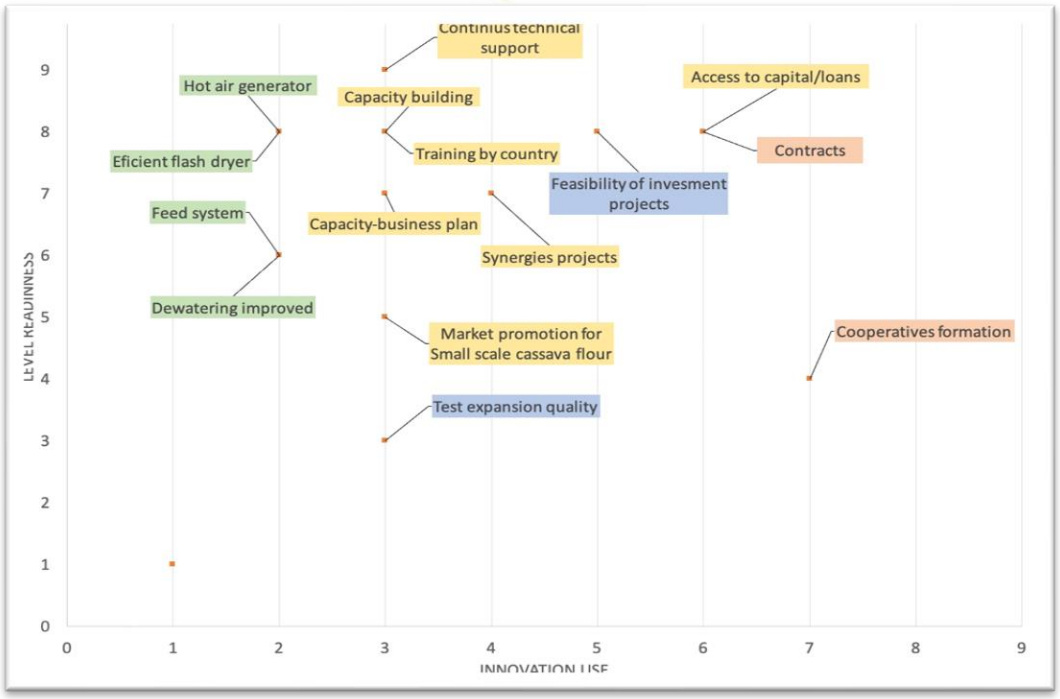


Figure 5. Scaling readiness diagram showing the innovation package for Colombia

(2) Fan/Blower: After the main drying tube and the heat exchangers, we identified the design of the blower as a third bottleneck towards designing energy efficient flash dryers with suitable production capacity. Current blowers generate air velocity of 4 to 6 m/s, which limit production capacity to 0.8 to 1 t flour/day. Fitting a larger blower (air velocity ~10m/s) can increase production capacity to 2.0 to 2.5 t flour/day. Hence the innovation package was updated to include a complementary innovation Fan/**Blower**. This additional innovation component is particularly relevant in Nigeria and DR Congo, for retrofitting existing flash dryers when possible.

2.1.5. Explain if and how the changes have enhanced or will enhance the scaling potential and /or the technical, economic, social and environmental viability of the innovation package.

If the cassava flour market is analysed, appropriate strategies could be formulated to enable flour processors in Nigeria and Latin America to access it. As in DRC, a continued demand for cassava flour will in principle ensure that the use of the innovations that this project aims to scale up will increase. The economic dynamization of the market will generate positive impacts on the quality of life of families of root producers and cassava flour processors, as well as of consumers, by increasing the supply of high quality food.

On the other hand, modifying the design of the fans will positively impact the efficiency of the flash dryers, increasing the air speed inside the drying system, increasing the production capacity and optimizing the use of electric energy. This will impact the profitability of the drying and flour extraction process, and consequently the quality of life of cassava processors and their workers.

2.1.6. Explain whether and how the Scaling Fund project characterized the scaling context (other projects, stakeholder networks, etc.) in the locations where scaling is aspired.

The stakeholder management strategy for the project done by Dr. Alejandro Taborda. Dr. Simon Lukombo, Dr, Suraju Adegbite and Dr. Murat Sartas following the **S**takeholder **E**ngagement **A**pproach for **S**caling in threes (***SEAS-3^n***). SEAS-3^n is a unified approach, developed by Dr. Murat Sartas, for combining identification of stakeholders in 3 steps, assessing their involvement in 9 levels and engaging them through 27 options. Initially, it describes the Flashdryer System. Afterwards, it presents its stakeholders in DRC and Nigeria, the involvement level of each stakeholder in the system and the innovations it works on as well as the best strategic stakeholder engagement option that improves the involvement.

For example, most of the stakeholders of the Flash Dryer System in DRC are not users yet. 9 of them are not aware of it yet, 12 of them are not using it although they are aware. This indicates that currently the priority of the stakeholder engagement activities in the DRC needs to be in creating awareness and supporting the early use of it among its stakeholders. The Flash dryer system in DRC has a significant number of developers (Figure 6).

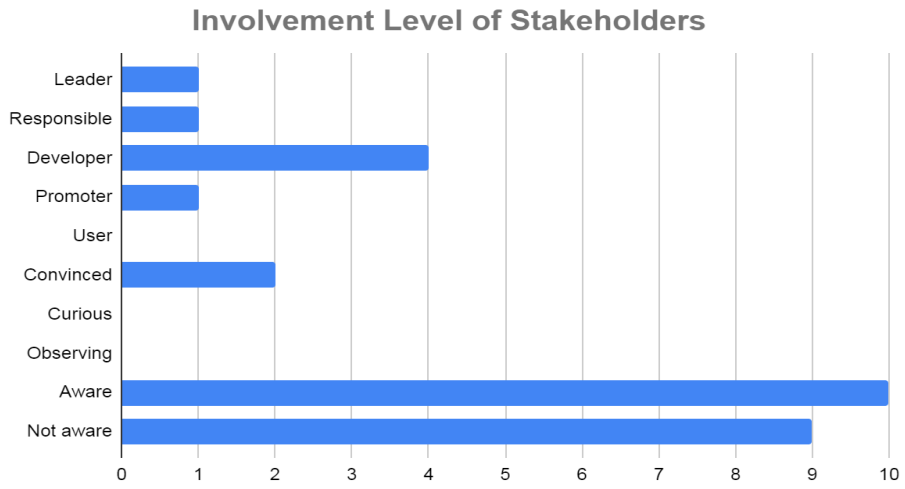


Figure 6. DRC Example: " Involvement Level of the Stakeholders

Considering the DRC context, the project aims to scale the Flash Dryer system, and the most effective activities that can improve the awareness of stakeholders are using social media materials and sending short messages for cellular phones. For supporting the early use, we recommend using factory visits (Figure 7).

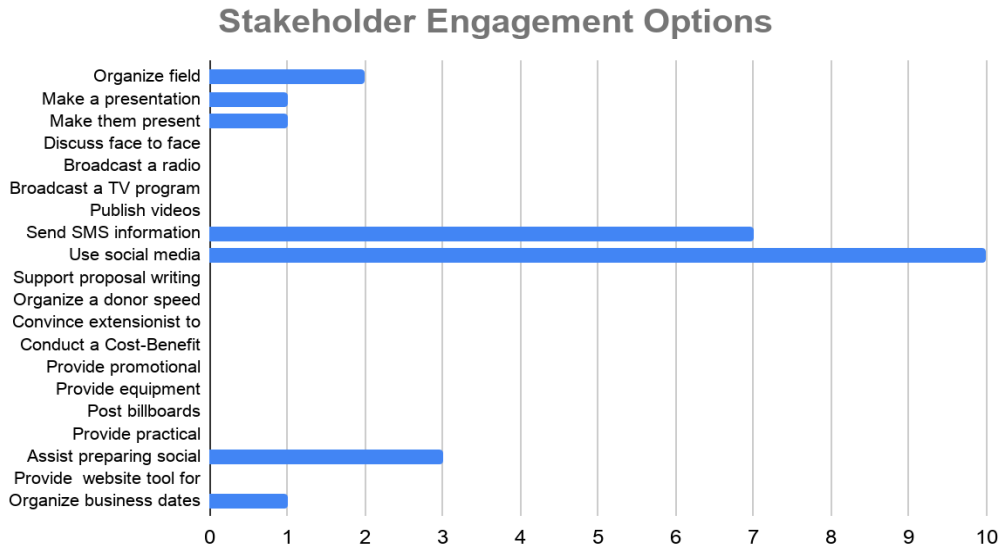


Figure 7. DRC Example: "Best Strategic Engagement Options to Increase Involvement"

Aditionally To characterize the context in each country where the innovations are to be scaled up, the virtual survey "*Stakeholder profile*" was initially used developed by Murat Sartas. This was completed by 21 project partners, including processors, equipment manufacturers, researchers, cassava producers, and others. The information captured is valuable for planning the phasing work. An example of this is shown in Figure 8. The only social network or text message communication platform that 100% of respondents have access to is WhatsApp. This result justifies the formulation of a technical support platform, using a chat group on WhatsApp.

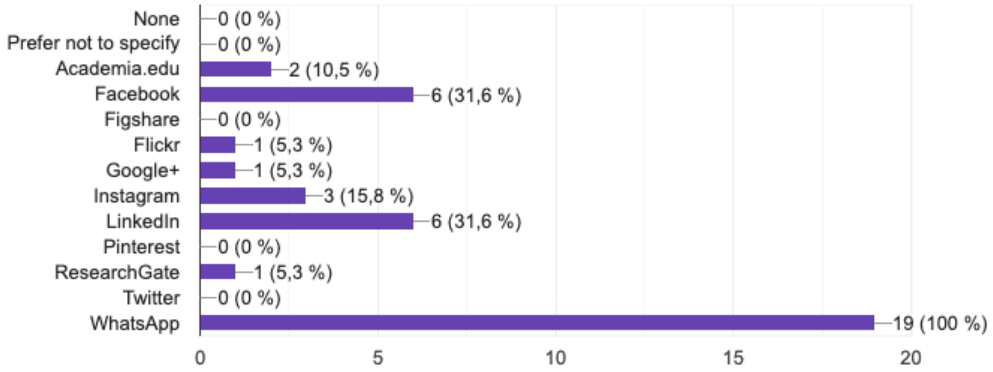


Figure 8. Example: "Stakeholder profile" survey output, use of social networks by Scaling Flash Dryer project partners.

Additionally, it was identified which are the projects in current execution and institutions with which synergies can be generated that would dynamize the process of staggering the innovations of the drying technology in the respective countries.

In Nigeria, for example, the TAAT research program, led by IITA, the *Scaling Flash Dryer* project, was approached and participated in the TAAT workshop held in Abuja in July. One

of the main objectives of this workshop was to bring together different actors in the **national** cassava processing value chain in order to organize a network that would drive the market, technology adoption, access to knowledge, capital and technology, among others. This event was attended by: bankers, representatives of cassava producers' associations, government representatives, researchers, representatives of development agencies, processors, root producers interested in processing (or improving their processing of), among others.
On the other hand, both in Nigeria and in DRC, meetings were organized with different actors of the value chain at the **regional level,** the objective was to publicize the *Scaling Flash Dryer* project, and to generate discussion panels among the invited stakeholders about which are the main technical, economic and political-administrative bottlenecks, which prevent the progress of the cassava chain.
In Colombia, we worked closely with the equipment manufacturer to build proposals for manufacturing flash dryers consistent with the needs and capabilities of potential customers, and with the higher education institutions that lead innovative projects that must incorporate flash drying. In the Dominican Republic, potential US traders were contacted for cassava flour to be produced by the Dominican Republic's Angavil company.

2.2. Step 2: Diagnosis

Identification of bottlenecks for scaling for each of the locations

2.2.1. Explain how the innovation package was assessed for (i) innovation readiness and (ii) innovation use for the different locations where scaling is aspired.

Table 6 summarizes the different strategies for capturing information required to analyze the level of "innovation readiness" and "innovation use" in the present project.

Table 6. Strategies for capturing information for the analysis of "innovation readiness" and "innovation use" of the present research project

Strategy for information capture	**A. Latina**	**Nigeria**	**DRC**
Virtual survey "*Diagnosis Survey For Flash Dryer"* formulated by Murat Sartas, and applied to the participants of the flash drying workshop held in August 2019 at CIAT, Colombia			
Technical visits to the companies - partners of the Scaling project, to know their production systems, technical and particular requirements of their productive context.			
Tests to measure the performance of the drying technologies currently operating in these companies.			
Discussion workshop with stakeholders in the cassava flour value chain (bankers, researchers, processors, manufacturers, Government Rep., international organizations. others) on the main barriers to scale of flash drying technology.			
Survey 41 cassava processors that have flash dryers. Characterization of processing systems, use of complementary technologies in flash drying, market, access to capital, others.			

Survey formulated to capture specific information for each innovation component, with particular questions to each stakeholder involved (directly or indirectly) in the Scaling Flash Dryer project and/or the cassava flour value chain.			

2.2.2. Explain who assessed the (i) innovation readiness and (ii) innovation use of the different core and complementary innovations in the package

Based on the innovation packages defined for the Flash Dryer scaling work in Nigeria, DR Congo and Colombia, the project team assessed the innovation readiness and innovation use. The first step to determine the innovation readiness and innovation use level was to collect background information via a short desktop study. The Scaling Readiness monitors gathered information about the available evidence on the readiness and use of the innovation package core and complementary innovations from academic and technical databases and repositories. To complement the desktop study, the project team also collected new data. For the innovations categorized as *products*, cassava processors and flash dryer manufacturers were visited at each location to collect technical information used in the analysis. For innovations categorized as *services*, *practices* and *institutional arrangements* (see Table 5), information was collected through surveys with different value chain actors, such as bankers, cassava producers, processors, and representatives of government organizations, among others. These surveys were administered during stakeholder meetings and forums in each location.

The information collected via the desktop review, field measurements and survey results were processed by the Scaling Readiness monitor to determine the innovation readiness and innovation use level for each of the innovations in the innovation package for the three country contexts. A Microsoft Excel template was used to plot the Scaling Readiness graph. The template enabled selection of innovation readiness and innovation use levels from a drop-down list and automatically generated the graph (see Figures 3, 4 and 5). To validate the results, the Scaling Readiness monitor presented the template to the project team and collaborators, as well as to other key project partners who made their contributions.

2.2.3. Explain whether the identified bottlenecks differed across the locations where scaling is aspired

The barriers identified differ from country to country. The main differences lie in the market for flash-dried products, and the use of this drying technology:

- **Latin America:**

Colombia does not have an open market for cassava flour; there is a potential use of the flour for the production of animal feed supplements within an integrative project that includes the use of flash drying technology. Interested investors are currently in the initial steps of searching for capital for implementing such project. On the other hand there is a large market for cassava sour starch, however the drying technology cannot fully replace traditional solar drying, because sunlight is required to obtain the expansion quality in the final products (snacks and bakery products). Another potential market is the production of cassava starch for the manufacture of bio-plastics. The Universidad del Cauca is currently leading a pilot

project on this, and is discussing collaboration with the RTB Scaling project to provide technical training in 2020 on the operation of a flash dryer. What justifies the participation of the scaling flash dryer project in these initiatives is the modest amount of resources needed, versus the high potential gains once the economic viability of these initiatives is demonstrated, opening the way for private entrepreneurs to replicate the models.
Dominican Republic produces cassava products for both internal market and exports, thanks to its location in the Caribbean. Demand for cassava flour or starch is a bottleneck that needs to be explored further in both these markets. The project partner, Angavil, is a small-scale cassava processors producing mainly casaba, and studies the possibility of entering the cassava flour market and investing in the flash dryer.

- **Africa**

Nigeria: The market for cassava flour is not adapted to small-scale producers, which is the main reason why 32 flash dryers (out of 64 known flash dryers) are not operating. The rest operate on an occasional basis. There are at least three known "generations" or types of flash dryers, which have been in popular use since about 2005. None of these designs have proven to be efficient, and over time, the new generations of dryers, instead of improving performance and efficiency, seem to be getting worse. For example, the *Open Door System* processor, partner of the Scaling project, has three dryers of different generations, however the only one that operates occasionally is the oldest one, (the first generation of dryers) because, according to him, it is not viable to process with the other two.

Democratic Republic of Congo: There is a growing demand for cassava flour (for the preparation of a traditional African dish called "*Fufu"*). Consequently, there is a growing interest among cassava processors to replace solar drying of flour and to acquire flash drying technology. There are currently few flash dryers in the country, partly due to high manufacturing prices (twice as much as a flash dryer in Nigeria) given the high costs of materials such as steel.

2.2.4. Explain whether the identified bottlenecks differed from those that were identified in the Scaling Fund project proposal.

The bottlenecks formulated in the initial proposal have not been changed. However, two new bottlenecks were identified: 1) the need to enter the cassava flour (NG) market, and 2) the need to improve the design of the manufacturing of flash dryer fans (NG and DRC).
It was thought that the main reason why small-scale flash dryers in Nigeria did not operate regularly, (or stopped operating) was mainly due to the low energy efficiency that makes the process economically unviable. However, it was found that in addition to this bottleneck, another barrier that seriously prevents the staggering of innovations (central and complementary) is that the production capacity of these small processors does not correspond to the order size of potential cassava flour buyers. This limits the access of these producers to the flour market in their country.

Remarks/ comments/ feedback on Step 2:
Provide short narrative update on how Scaling Readiness was applied and supported the diagnosis of bottlenecks for scaling.

In 2019, information is collected through different mechanisms to determine the degree of use and state of readiness (suitability) of the innovation components. This was done through technical visits to the production plants, also by measuring the performance of 4 flash dryers currently operating in Nigeria and Congo, and three different types of surveys (see table 6) applied to the actors of the starch/yucca flour value chain in the three countries, among which the project partners. The analysis of this information allowed the identification of the main bottlenecks that prevent the staggering of the innovation package.

2.3. Step 3: Strategize

Scaling strategy

- Present the scaling strategy defined at the beginning of the project

"The scaling strategy follows a straightforward approach of (i) training on the technical and socio-economic aspects of the technology, including development of business plans by the scaling partners, (ii) implementation of the investment plan, (iii) design, construction and commissioning of flash dryers by the scaling partners with constant support from project scientists and scaling champions, through on-line technical consultations, regular on-site visits, and Year 1 debriefing workshop, (iv) end-of-project debriefing workshop, outcomes assessment and lessons learned evaluation. Successful scaling of flash drying would require that the following constraints are overcome or minimized: Access to investment capital; Stable access to cassava roots at cost-effective prices; Availability of skilled engineering skills to conduct maintenance and repairs in a timely manner".

- Explain which strategic option was selected (substitute, outsource, develop, etc.) to overcome the bottlenecks for scaling in the different project locations

In Nigeria, the main bottleneck were market options for cassava flash drying and inefficient fan/blower increasing the cost of drying (Figure 3). The customers of cassava flour (e.g. millers, brewers), required much higher volumes than can be supplied by small-scale producers. The buyers typically demand 30 or 60 tons per order, whereas some of the small-scale cassava flour factories can produce up to 1 to 2 tons per day. This led to underutilization of the flashdrying capacity since some of the producers were not economically viable options for the large-scale buyers. Only32 flash dryers (out of 64 known flash dryers) were viable for the cassava flash drying. , To increase the market options available for vacant small scale flash dryers, the team has decided to explore production of yam flour, instead of cassava, that can be sold to millers in much smaller volumes. Another bottleneck for flash drying in Nigeria was the fan/blowers of the drying system. The team has developed the fans/blowers of the drying system by designing improvements and testing them in the flash drying producers' workshops (Table 5.)

In the DR Congo, similar to Nigeria, the main bottleneck was the fans/blowers (Figure 4). The capacity of fans to achieve adequate air velocity was too low, resulting in low production capacity. Equipment manufacturers acknowledged that they did not have enough experience to build larger fans (due to balancing issues with the rotor) and that they did not know the methods to determine the efficiency of the fan (e.g. air velocity measurements). To address this need, the complementary innovation flash dryer fans/blowers was added to the

innovation package. The team has worked on developing the fan and calibrating it for efficient drying.(Table 5).

In Colombia, following the lack of agreement and changing context, a reorientation and relocation strategy has been implemented simultaneously. Regarding relocation, the Flash Dryer project team has facilitated linkages between manufacturers in Colombia and Dominican Republic. However, another unforeseen challenge emerged in the drafting of the contract between the Colombian manufacturer ENSO and the flour processor ANGAVIL in the Dominican Republic, as neither of them wanted to be responsible for a possible cost overrun due to remanufacturing in the setting up of the flash dryer. By the time of the writing of this chapter there was no clear solution to the issue.

Simultaneously, the use of flash drying technology was reoriented towards the production of high-grade cassava starch for bio-plastics. This initiative is led by Universidad del Cauca and a start-up company in Colombia, and funded by Colciencias, the national agency for scientific development. The funding by Colciencias includes construction of a flash-dryer outsourced from a Chinese manufacturer (Agro-Bio-Tech Co-ltda). The Flashdryer project team provided technical backstopping and facilitated the establishment of flash drying technology in Colombia, in line with the project's objectives.

Table 7 present the strategic options selected tovercome the bottlenecks for the different project locations.

Table 7. Strategic options selected to overcome the bottlenecks for scaling in the different project locations

Bottlenecks	Strategy Proposed	Location
The production capacity of small processors does not correspond to the order size of potential cassava flour buyers. This limits the access of these producers to the flour market in their country.	Reorient	Nigeria
The capacity of fans to achieve adequate air velocity was too low, resulting in low production capacity (see Figure 3 and 4).	Develop	Nigeria and DRC
The cassava sour starch value chain did not adopt flash dryer technology because solar drying is necessary for the expansion of breads, snacks and others.	Reorient	Colombia
	Relocate	Dominican Republic

- Explain how the decision of how to overcome the scaling bottlenecks was taken by the project and the key stakeholders.

Table 8. Strategic options selected to overcome the bottlenecks for scaling in the different project locations

Bottleneck Innovation	Location	Strategy Proposed	Strategy description (how decision was taken)

Cassava flour production option: The production capacity of small processors does not correspond to the order size of potential cassava flour buyers. This limits the access of these producers to the flour market in their country (see Figure 3).	Nigeria	Reorient	While working on strategies to enable small-scale cassava flour producers to access the market, the potential use of flash drying technology for drying yam flour was identified. The company Goldbridge Foods Limited acquired a flash dryer developed based on the CIAT prototype, and manufactured by one of the partners of the Scaling project (Hickman Engineering). In addition to Cassava flour, yam flour was added to the production options of the Flash Dryer.
Fans: The capacity of fans to achieve adequate air velocity was too low, resulting in low production capacity (see Figure 3 and 4).	DR Congo/ Nigeria	Develop	In most cases the power of the fans were too low to achieve adequate air velocity, resulting in low production capacity. Some equipment manufacturers acknowledged that they did not have enough experience to build larger fans (due to balancing issues with the rotor) and that they did not know the methods to determine the efficiency of the fan (e.g. air velocity measurements). To address this need, the complementary innovation Flash dryer fans/blowers was added to the innovation package. The team has worked on developing the fan and calibrating it for efficient drying.

Sour starch production option: The cassava sour starch value chain did not adopt flash dryer technology because solar drying is necessary for the expansion of breads, snacks and others. Moreover, the quality of the starch expansion in the tests where solar drying was combined with flash drying, did not have good preliminary results (see Figure 5).	Colombia	Reorient	The use of flash drying technology was reoriented towards the production of high-grade cassava starch for bio-plastics. This initiative is led by Universidad del Cauca and a start-up company in Colombia, and funded by Colciencias, the national agency for scientific development. The funding by Colciencias includes construction of a flash-dryer outsourced from a Chinese manufacturer (Agro-Bio-Tech Co-ltda). We took this decision to reorient in order to provide technical backstopping and facilitate the establishment of flash drying technology in Colombia, in line with the project's objectives. This decision was facilitated by the small amount of resources necessary from the Scaling project to contribute.
	Colombia -> Dominican Republic	Relocate	In complement to the reorient strategy in Colombia (details above), diversifying the locations appeared important in order to increase the chances of successful establishment of flash dryers in commercial use in Latin America. Therefore we decided to provide technical support to the Angavil company to develop its investment plans in flash drying technology for production of cassava flour in the Dominican Republic.

- Explain how the (re)assessment of the innovation package, identification of bottlenecks, selection of strategic options influenced resource allocation under the Scaling Fund project

Initially, the strategies selected in Colombia did not significantly affect budget allocation. Because the resources selected for the technical visits and data collection visits were used equally, but now with potential users of the flash dryer technology in Colombia and the Dominican Republic.

However, by the end of the project, the partners in the Dominican Republic and Colombia had not been able to invest in flash drying innovations, mainly because they were affected by the pandemic. Therefore, it was decided to use part of the budget for the development of an

open web tool that will serve for business plan analysis and investment in cassava flour processing. The tool will include instruments for the design of energy-efficient flash dryers.

In Nigeria, after identifying the main bottleneck and selecting strategies, part of the budget was used to manufacture a prototype flash dryer that will serve as a pilot to promote the use of flash drying technology innovations in the region. Moreover, this prototype dryer will be a flash dryer model with a higher capacity (300 kg/h) than the current models. Once the dryer is completed, a workshop will be organized with cassava flour value chain stakeholders in Nigeria.

- Explain what new activities were invested in based on the assessment and decisions on strategic options.

Figure 9 presents the evolution of the strategies selected to overcome the main bottlenecks in each country. It indicates at what point in time: i) the bottleneck was identified, ii) the strategy considered appropriate to overcome the bottleneck was selected, iii) other underlying bottlenecks emerge, iv) the strategies are evaluated and it is decided to stop those that did not produce the desired results.

The lessons learned was that it is not enough to carry out this analysis only at the beginning of the project, but that periodic diagnoses must be carried out, since the context is dynamic and changing, and *emerging* bottlenecks can arise. Likewise, it is convenient to carry out *multi-level diagnostics* in order to find root causes, that is, those barriers that are not evident at first sight but that also condition the progress of the scaling process. We conclude that it is not enough to focus only on technical aspects associated with the innovations; socioeconomic aspects of the context must also be analyzed and addressed. In addition, it is important to take into account the opinions of different actors in the value chain during the *Agree* Step 4, since different perspectives contribute to the design and implementation of realistic strategies. An interdisciplinary team should be involved in processing and analyzing the highly complex information in order to transform it into appropriate and acceptable scaling strategies.

Partnership strategy

- Present the network of partners that have been involved in the scaling projects. Explain how partners and partner modalities were identified.

Table 9 present the network of partners linked to the Scaling flash dryer project in the different locations. In each country, the respective "Scaling champion" identified and proposed the project partners with the greatest potential for adopting the innovations to be scaled, according to their experience and knowledge of the cassava value chain.

During the flash drying workshop held at CIAT, Colombia, all the partners listed in table 9 were present. At this occasion small networks were created made up of (i) cassava processors interested in investing in flash drying technology, (ii) equipment manufacturers that would

be contracted to build the equipment, and (iii) the technical team and phasing support of CIAT-CIRAD-IITA, responsible for advising on the design, manufacturing, installation and testing stages of the equipment. These small networks are linked through chat platforms (whatsapp) and e-mail to share experience of their constructions, manufacturing costs, designs, among other useful information, in the form of text, photos and videos.

Table 9. Network of partners that have been involved in the scaling projects

Partner Modalities	First name	Family name	Company	Country
HQCF Processors	Emmanuel Oluwole	Olatunde	Open Door System	Nigeria
	Jimoh Lambo	Akanbi	Arogunjo Farms	
	Adedotun Emmanuel	Alade	Oyo Ifelodun Cassava Processing CICS LTD	
	Donatus Emwinghare	Imaghodor	Lentus Food	
Equipment manufacturers	Lukman Adekunle	Ishola	Hickman Ventures	
	Adeniyi Ganiyu	Ogunkoya	Deban Faith	
Scaling Champions	Suraju Adeyemi	Adegbite	FIIRO / IITA	
	Simon	Lukombo Singi Malundama	IITA	Democratic Republic of Congo
Equipment manufacturer	Mamadou	Ndiaye Kunga	Agrimac	
Cassava flour processors	Auguste	Sengo Nzuzi	Nutripro	
	Abdias	Niangisi Utono	Ecosac	
	Gaylord	Kuti Tubi	Layuka	
Cassava Starch processor	Joao	Bosco Carvalho	Polvilho Orivaldo	Brazil
Casabe (and flour) processor	Antonio	Garcia	Angavil	Dominican Republic
Cassava flour processor	Cristian	Castro	La Salle University	Colombia
Equipment manufacturer	Alberto	Garcia	Enso engineering	
Cassava Starch processors	Martin	Moreno	Univalle	
	Gustavo	Velez	Deriyuca	
	Javier	Sanchez	Starches 1a	
	Eider	Granda	Granda Starches	

Cassava producers	Oscar Hernan	Dominguez Q.	Cassava producer	
	Jose Elias	Rubio Quiroga	Cassava producer	
Spin off- Biodegradable processor	Hector Samuel	Villada	University of Cauca	

- Explain how partnerships are fit-for-purpose for overcoming the key bottlenecks for scaling

The initial workshop (August 2019) and following discussions through informal communication networks have resulted in relationships of trust that will help to overcome the key bottlenecks through the proposed strategies (see Tables 7 and 8). Some of the stakeholders already knew each other before the August 2019 workshop, which also facilitated the process. In Colombia, for example, the equipment manufacturer ENSO has manufactured equipment for cassava processing for Universidad de La Salle in the past. The quality of this equipment and its good functioning has facilitated the discussions around selecting and scaling the flash drying technology for Universidad de La Salle.

Another way how these partnerships help overcoming bottlenecks towards scaling is the technical support the project team (CIAT, IITA, CIRAD) is able to provide to project partners without costs, thanks to project's funding. Some of the project partners have indicated that this has contributed to fast-track their investment decision. This approach is sustainable as, once the project is completed, equipment manufacturers will be able to advise other processors on how to optimize their dryers, or design new flash dryers in their factories. The current partners of the project will be the future agents of the scale-up of flash drying innovations.

- Describe if and how the network changed (for example new partners, changes in the roles, strengthened capacities).

Some actors who initially expressed their intention to adopt flash drying technology, over time expressed their inability to do so for administrative and/or financial reasons, for example the company CULTUM in Colombia.
On the other hand, the equipment manufacturer Niji Lukas, initially consulted and proposed as partners for the Scaling project, in 2019 said that he could not continue to be linked to the project due to lack of time because he was involved in other projects.
Instead, other processors and manufacturers have been linked to the project in the course of 2019 and 2020. For example: the company ANGAVIL of the Dominican Republic, Goldbridge Foods Limited and Okunboh Foods Limited of Nigeria, the Universities of Cauca and Salle in Colombia, and FERME MAKOBI and FERME BIBWA in DRC (see tables 7 and 8).

- Present the key lessons learned in terms of partnership management and its importance for the scaling process.

The technical visits to the companies of the partners and potential partners (February to July 2019) were key to determine their actual needs, as well as to create bonds of trust. The workshop held at CIAT Colombia, attended by all the project partners (table 9) also allowed stimulating networking and exchange of knowledge and experiences among processors and producers from five countries (DRC, Colombia, Nigeria, Dominican Republic and Brazil).

For example, one section of that workshop let equipment manufacturers exchange their experience on manufacturing techniques and equipment manufacturing tools for the food industry (figure 7). The result of this exercise was that in the following technical visit carried out in November 2019, the Nigerian and DRC manufacturers had improved the quality of their work (with respect to what was seen in July of the same year), such as welding and polishing.

Figure 7. Exchange of design and manufacturing techniques and methodologies by manufacturers in Colombia, Nigeria and DRC.

In the course project implementation, differences emerged between countries in terms of the distribution of responsibilities between processors, equipment manufacturers and project scientists, in relation to the level of investment and estimated financial risk. In DR Congo, cassava processors were confident in the market for cassava flour, which is a staple food product in this country, and therefore were willing to invest in flash dryers and to assume the financial risks without needing a formal agreement. In Nigeria, the market for cassava flour is not functioning smoothly due to a combination of factors such as low availability of cassava roots at competitive price for flour production; high processing costs due to low energy efficiency of current flash dryers; and mismatch between production capacity of cassava processors and demand from large buyers). Consequently, cassava processors were less confident in shouldering investment risks, with the majority preferring to wait for one successful implementation of the flash drying innovation before investing themselves. In Latin America, investment costs, and hence financial risks, were significantly higher due to higher labor costs and other constraints. In addition, the market for cassava flour is not mature yet. Consequently, cassava processors were not willing to fully take on the investment risks, and required that equipment manufacturers or the Flash Dryer Scaling Project offer guarantees against construction cost overrun and potential financial underperformance of the flash dryer system. This led to negotiations and written agreements in the form of a sales contract between the cassava processor and the equipment manufacturer.

This underlines that scaling projects always entail financial risk-taking, considering that innovations, by nature, are not yet fully proven with guaranteed return on investment when introduced in an uncontrolled (market) situation. A key bottleneck is therefore agreeing between project partners who will take on responsibility for these risks. One option to manage such bottleneck is to identify and select early in the project private partners who are in a position to accept the risks, i.e. financial capacity for investment, confidence in the benefits of the innovation, as well as access to technical expertise to correct potential issues, including after the construction and delivery of the equipment (Cox and Stevens, 2001).

Remarks/ comments/ feedback on Step 3:

Provide short narrative update on how Scaling Readiness was applied and how this influenced the project capacity of strategizing towards overcoming key bottlenecks for scaling the innovation package?

In February, the project partners were visited in Colombia to plan the process of scaling up the drying technology. In April, training was received on the principles and procedures of "Scaling Readiness". In July the first technical visit to the project partners in Nigeria and DRC was made to carry out diagnostics in the companies of equipment manufacturers and cassava flour processors, partners of the Scaling project. In August the small-scale flash drying workshop was held, where after presenting the objective and scope of the project to the invited partners from DRC, Nigeria, Colombia, Dominican Republic and Brazil, they were given training in technical aspects of flash dryer design and manufacturing. Also financial training on how to elaborate a business plan to analyze the viability of the investment to modify (improve) and/or manufacture a flash dryer (and/or complementary equipment to the drying technology). In November a new partner in the Scaling project in Colombia was visited who would adopt the innovations for a purpose not identified in the project formulation (for yucca meal-animal feed and livestock). In December 2019 technical visits were made to measure the efficiency of the flash dryers currently operating in DRC and Nigeria, some of these dryers had already modifications and improvements according to what was learned in the flash drying workshop in Cali Colombia. Those project partners who started manufacturing and/or modifying their equipment since 2019 were provided with continuous technical support: from design and manufacturing to installation and measurement of the efficiency of the drying process. Although in 2020 the pandemic limited face-to-face technical visits, virtual meeting platforms were used periodically to continue to provide technical and financial support, as well as to collect information on the progress of scaling up innovations.

Step 4: Agree

- Explain how the draft Scaling Strategy was shared and discussed with the broader stakeholders in the different locations where the project is active

During the "*Scaling Readiness Kick-off*" held in April 2019, in Nairobi, an exercise of analysis and discussion was carried out to determine which would be the components of innovation to be scaled and the main bottlenecks or barriers to this scaling process. This activity involved: the project leader, the scaling monitor, the "Scaling Champions" from DRC, Nigeria and Colombia, and project advisors and supervisors. The main phasing

strategies were established for each country and for each phasing barrier. The resulting document would become the navigation chart for planning activities for the professionals linked to the project responsible for the phasing, and for determining and identifying the suitable project partners. This document was shared with all extended stakeholders.

- Explain whether and what changes were made to the location-specific scaling strategies (e.g. exploring new strategic options) based on stakeholder consensus seeking and negotiation

In Colombia, negotiations were held with the company CULTUM, interested in obtaining the technology for flash drying, that the project would finance the manufacture of the drying equipment while the company CULTUM would invest in the land, infrastructure and complementary technologies for the processing of cassava. This negotiation was not approved by the project's directives, which established that any project partner should invest its own resources or seek funding for the project. The Scaling project would finance technical and financial capacity building activities through training, technical support and consultancy. CULTUM would accept these new conditions, however by 2019 and 2020 it would not be enough time to secure funding for this project. This led to a search for alternatives and new partners with whom to work in scaling the innovations of flash drying technologies.

Figure 9 shows the changes in the strategies that were implemented during the project. In Colombia, it was decided to **reorient** the use of flash-drying technology for processing cassava flour for animal feed. It was also **relocated** to work with the ANGAVIL partner in the Dominican Republic. These two strategies were affected by the pandemic, so it was decided to **stop** the strategies and **reorient** the work to the **development** of a web tool for business analysis in the production of cassava flour. Another strategy in Colombia that was also affected by the pandemic was to **reorient** the use of starch processing technology used in the manufacture of bioplastics. Although it was not stopped, there were delays in its implementation.

On the other hand, in Nigeria, it was decided to **reorient** the use of flash technology to produce yam flour. This strategy was subsequently **stopped** because the yam flour processor, after paying for the flash dryer and installing it in his company, decided that he would not use it because it "did not fit his processing logistics".

- Explain the implications of the changes to the location specific scaling strategies for the overall scaling ambitions of the project

Changes in the location of some activities were made to diversify the number of partners, and thus increase the chances of successful development of flash dryers under commercial use by the end of the project. This implies more communications with and visits to the increased number of partners, and is possible using only the resources initially planned for the project, because the newly coopted partners all take responsibility for the investment in the construction of the equipment, and only require technical support, through internet-based discussions and meetings, and occasional field visits.

- Explain how the scaling strategy was operationalized into a scaling action plan.

Based on the construction of the strategies described above, a set of activities was established in order to overcome the phasing barriers identified for each country. The deadlines for delivery of results were agreed among the team members: S. Champion, and S. monitor, together with the project leader and respective supervisors, in order to monitor the progress of each strategy. Collecting information regularly was fundamental for decision making. Communication between team members from various countries allowed us to evaluate and adjust the chosen strategies.

- Explain whether and how any reallocation of budget and roles were made and agreed upon with the main project partners and stakeholders.

Initially, the strategies selected in Colombia did not significantly affect budget allocation. Because the resources selected for the technical visits and data collection visits were used equally, but now with potential users of the flash dryer technology in Colombia and the Dominican Republic.

However, by the end of the project, the partners in the Dominican Republic and Colombia had not been able to invest in flash drying innovations, mainly because they were affected by the pandemic. Therefore, it was decided to use part of the budget for the development of an open web tool that will serve for business plan analysis and investment in cassava flour processing. The tool will include instruments for the design of energy-efficient flash dryers.

In Nigeria, after identifying the main bottleneck and selecting strategies, part of the budget was used to manufacture a prototype flash dryer that will serve as a pilot to promote the use of flash drying technology innovations in the region. Moreover, this prototype dryer will be a flash dryer model with a higher capacity (300 kg/h) than the current models. Once the dryer is completed, a workshop will be organized with cassava flour value chain stakeholders in Nigeria.

- Explain how overall agreement on the scaling strategy and action plan were documented.

In the case of strategies and activities for professionals linked to the phasing project, the objectives were documented in an Excel matrix shared with all project members. The monitoring of activities was recorded monthly in the "TECHNICAL REPORT FORM" given to the project leader and supervisor.

On the other hand, the manufacturers and processors who are partners in the project, stated in writing what their activities and commitments would be to the project through a signed "participation agreement". Similarly, by means of a "letter of thanks" they expressed in writing how the knowledge acquired in the small-scale flash drying workshop in August, in Cali Colombia, would serve to improve their production processes and the efficiency of their processes.

Remarks/ comments/ feedback on Step 4:

Provide short narrative on how Scaling Readiness was applied and supported the stakeholder negotiations and development of the scaling action plan in the scaling fund project.

In April 2019, the project leader, project advisors/supervisors, S. Champions, and S. Monitor, jointly analyzed the main strategies and activities to overcome the scaling bottlenecks in each country where the project is active. Each member of the team contributed to the construction of an activity plan consistent with each strategy and each innovation component to be scaled.
In August 2019, the project's processors and manufacturer partners expressed their intention to participate in the development of the phasing project activities in writing. Furthermore, the financial planning exercise allowed them to make financial agreements between manufacturer and processors, to plan modifications and/or construction of flash dryers.

Step 5: Navigate

- Explain how scaling strategy and scaling action plan implementation was monitored

The phasing strategies and the respective activity plan were formulated in order to comply with the project's *outputs* and *outcomes.* The collection of qualitative and quantitative data as outputs of each proposed and executed activity, was recorded in different deliverables with the aim of bringing together a set of evidence, experiences and learning that would portray the history of progress in the staggering of the flash drying technology.

- Explain what kinds of changes were made to the scaling action plan in terms based on monitoring and evaluation and learning

The monitoring indicators for the strategic plan and activities were formulated with the objective of achieving or materializing the *outputs* and *outcomes* formulated for the project. The measurement of these indicators was recorded and consolidated in documents (deliverables) for the evaluation of the quality of the phasing process.
In order to know the progress of the scaling up of each innovation component, 3 types of surveys were used to know the degree of adoption by the project partners.
As part of the MEL Project, a strategy to monitor the progress of the project, it served to record and analyze the results of each initiative, and to process this information objectively to extract lessons and reflections on how to improve the phasing process for the second year of the project.

- Explain how principles of reflexive learning were implemented as part of the projects MEL strategy

The data collected during project implementationfor the MEL indicators were mainly collected at the beginning of the project to establish a baseline of the situation in each country (Nigeria, DRC, Colombia) before the introduction of the flash drying technology (or new generation of improved flash dryers).
To this end, an analysis of the current situation of the actors associated with the project (processors, equipment manufacturers) was carried out to identify those most likely to succeed in adopting the drying technology to scale.
In addition, a baseline of the situation of the environment of these entrepreneurs was established. In addition, the influence of aspects such as cassava production, current prices of roots and flour/starch, processing activities, knowledge of and access to technology, limitations and opportunities, etc., on staggering was analysed.
All this information, collected during project implementation, was analyzed in order to extract the main conclusions or learning reflections on the phasing process, for the improvement of the strategies.

Remarks/ comments/ feedback on Step 5:

In Nigeria, the implementation of scaling action plan was slower than planned, with most project partners delaying their decision to invest in the flash dryer innovations. Consultation with the different actors in the High Quality Cassava Flour value chain revealed an emerging bottleneck that had not been identified during the initial Scaling Readiness characterization and diagnosis steps, namely an increasing cost of cassava roots in 2020 that reduced the profit margin of processing. A detailed economic analysis corroborated that cassava roots are the main cost of flour production (on average 32% of the total cost of production, but up to 60-70% when other costs are optimized). This analysis revealed two additional bottleneck; few farmers apply good agricultural practices to their cassava crops, and there is little use of high-yielding genetic root materials. In order to achieve profitability in processing, it is necessary to reach production yields of up to 20-25 tons of roots/ha, against a current average yield of about 8-10 tons of cassava roots/ha. Although the Flash Dryer Scaling Fund project did not have the time or resources to contribute directly to the improvement of cassava production yields scenario, exploring *synergies with other projects* (see Figure 3) became an immediate priority and a cooperation with the African Development Bank funded Technologies for African Agricultural Transformation (TAAT) program were established. This program has, among others, the objective of providing technical assistance for efficient cassava root production in several African countries, including Nigeria. Overcoming this bottleneck will be key to reduce the cost of cassava roots and related bottlenecks on investment in processing of High Quality Cassava Flour.

In Nigeria and DR Congo the *heat exchanger* was developed with the goal of driving specific modifications to existing (diesel) heat exchanger designs as well as promoting the manufacture of a new, more efficient heat exchanger design. Out of eight initial private sector scaling partners, by end 2019 three have adopted this innovation and increased their processing capacity by 23% to 50%, and profitability by 8% to 10%, corresponding to extra income about 10,000 USD/year/processor. Cassava producers also benefit from a higher processing capacity, increases the demand for cassava roots, and hence economic opportunities for farmers in the regions around cassava factories. Since the most used fuel in Nigeria and DR Congo is diesel, the partners were recommended to change their heating systems to LPG, as long as the price of LPG is competitive in the region. This is a more cost-effective solution (because there is no need to manufacture a heat exchanger) and approximately 10% more efficient with respect to the use of diesel. In the year 2020 two partners of DR Congo invested in this innovation.

In the Dominican Republic, a scaling action plan was agreed in early 2020 between the cassava processor, equipment manufacturer and R4D team. The plan was then revised through short-term feedback loops several times. The main feedback was related to the definition of responsibilities for the investment risk, as the cassava processor wanted a guaranteed return on investment, while the equipment manufacturer or the R4D team could not take on this responsibility due to the novelty of the innovation. Each of the partners reviewed their expectations until the scaling action plan was revised and agreed upon.

Figure 8. Impact pathways - 2019 progress

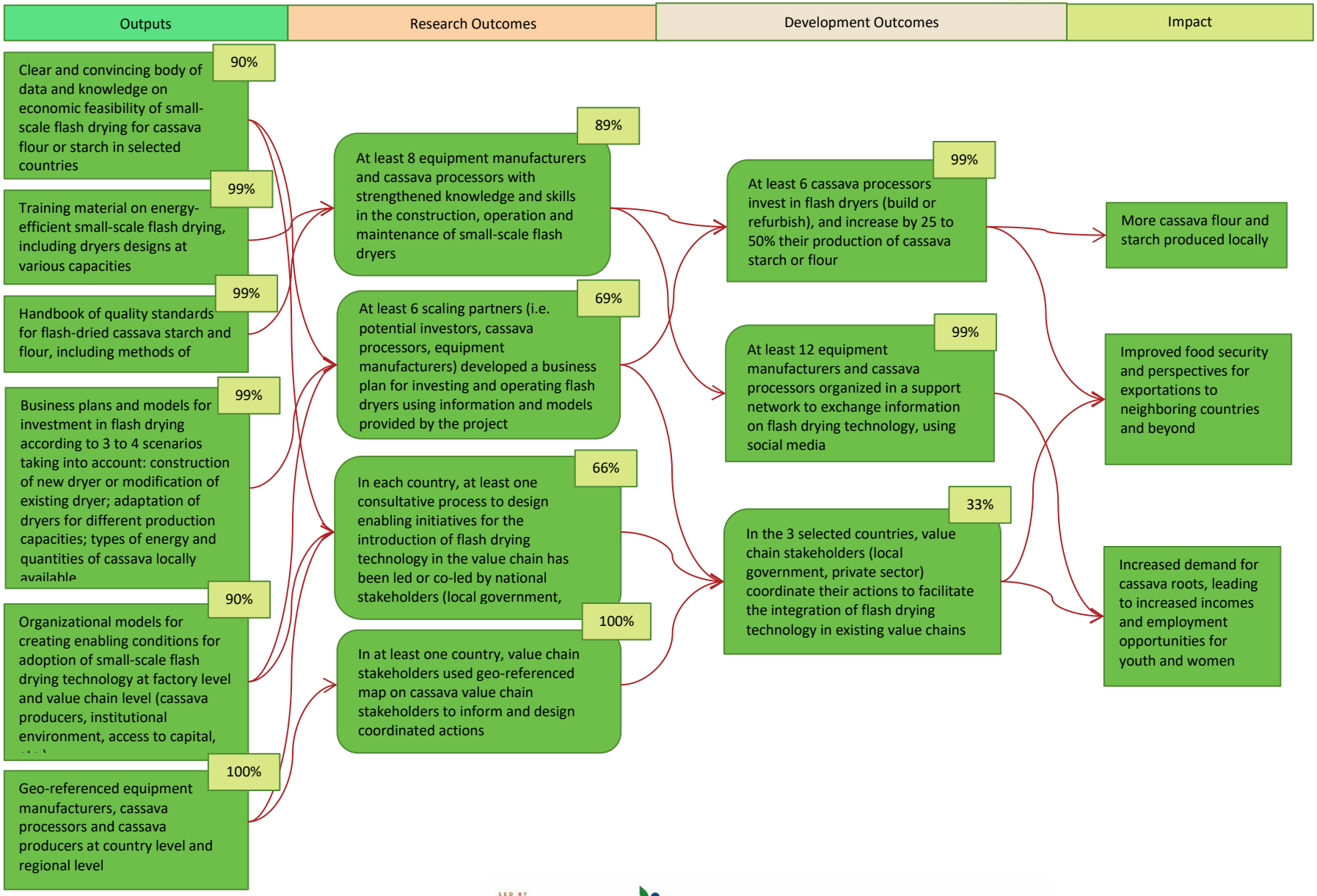
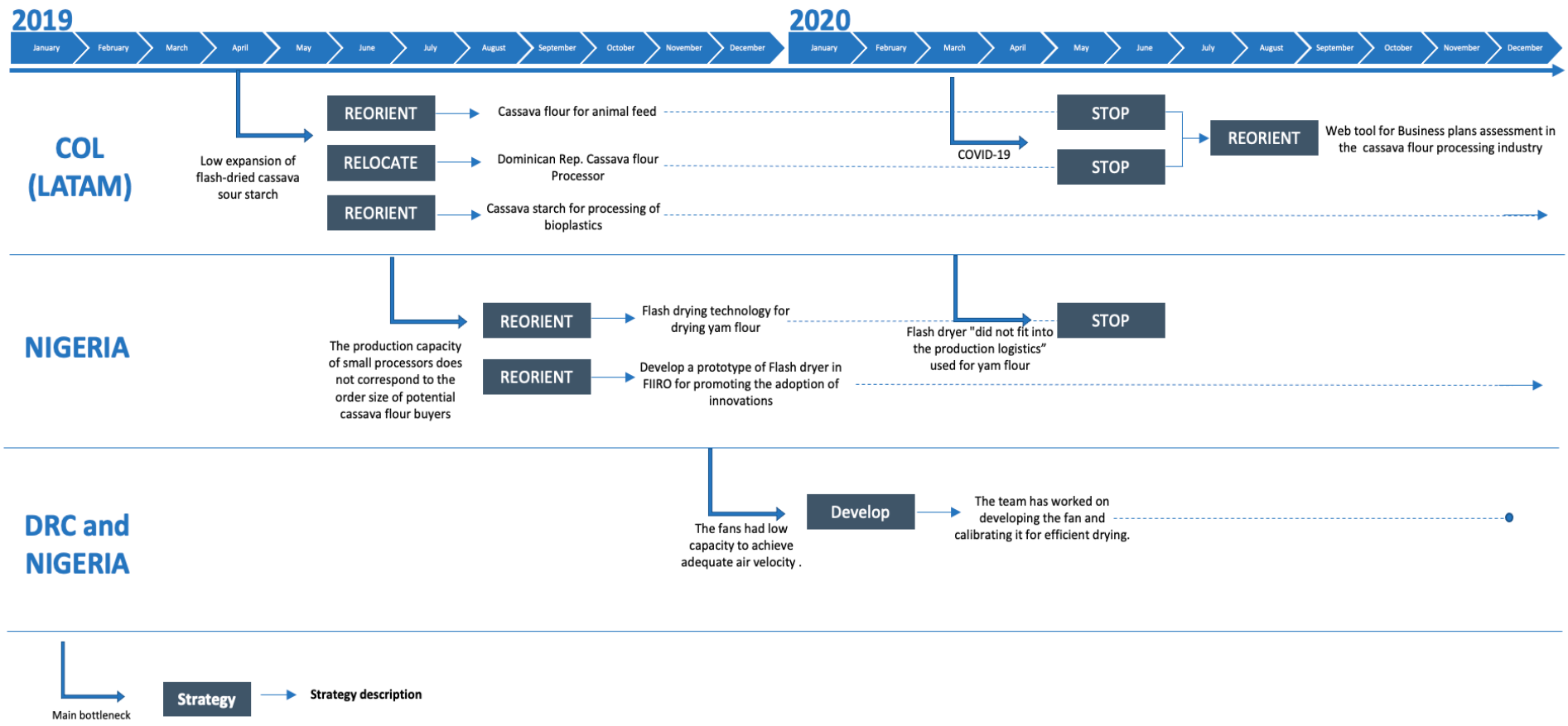


Figure 9. Evolution of the strategies during the development of the project.



Financial update

Present financial data using the standard cost categories

Categories	Y1 Budget (USD)	Y1 Expenses (USD)	Y2 Budget (USD)	Y2 Expenses (USD)
Personnel				
Collaborator Costs - CGIAR Centers				
Collaborator Costs - Others				
Supplies and Services				
Training / Workshop				
Operational Travel				
Depreciation				
Sub-total of Direct Cost				
Indirect Costs/Institutional Overhead (15%)				
TOTAL - all Costs				

CIAT

Categories	Y1 Budget (USD)	Y1 Expenses (USD)	Y2 Budget (USD)	Y2 Expenses (USD)
Personnel	75 095	43 948		
Collaborator Costs - CGIAR Centers	-	-		
Collaborator Costs - Others	-	-		
Supplies and Services	64 905	65 125		
Training / Workshop	40 000	40 369		
Operational Travel	25 000	31 252		
Depreciation	-	-		
Sub-total of Direct Cost	205 000	180 695		
Indirect Costs/Institutional Overhead (15%)	26 650	23 490		
TOTAL - all Costs	231 650	204 185		

Carryover will be used for salary costs during Year 2

IITA

Categories	Y1 Budget (USD)	Y1 Expenses (USD)	Y2 Budget (USD)	Y2 Expenses (USD)
Personnel	30,000	23,386		
Collaborator Costs - CGIAR Centers	0	0		
Collaborator Costs - Others	70,000	2,544		
Supplies and Services	25,000	94,914		
Training / Workshop	10,000	9,052		
Operational Travel	10,000	11,311		
Depreciation	0	0		
Sub-total of Direct Cost	145,000	141,207		
Indirect Costs/Institutional Overhead (15%)	15,950	19,742		
TOTAL - all Costs	160,950	160,949		

Present the level of co-investment mobilized

Categories	Main activities covered and geographical scope	Y1 Expenses (USD)	Y2 Expenses (USD)
Co-investor 1	TAAT Cassava Compact invested in: (i) the design and fabrication of the second 100% locally made flash dryer in the DRC. It is being installed in Eastern Congo. Additional machines were renovated to achieve a complete operation for making HQCF, and the processors are being trained on the use of the flash dryer (US$60,000). (ii) Rehabilitation of the flash dryer and electricity generator at Oyo Ifelodun Cassava Processing CICS LTD, in order to make the factory operational for	US$85,000	

	the implementation of the Flash Dryer Scaling Project (US$4,000) (iii) design and delivery of biomass-heated dryer at OpenDoor as alternative drying equipment for experimental comparison with the small scale flash dryer ($21,000)		
Co-investor 2	*Short narrative*		
Co-investor 3			
…			
TOTAL - all co-investors			

Annex 1. List of deliverables reported

Output	Deliverable	Description	Status
1. Clear and convincing body of data and knowledge on economic feasibility of small-scale flash drying for cassava flour or starch in Nigeria, DRC and Colombia	Presentation (AT)	Plan for the flash dryer	Delivered
2. Training material on energy-efficient small-scale flash drying	Presentation (TT)	Training material: Presentation overview of small-scale efficient flash dryer development since 2014	Delivered
	Training Material (AC)	Tools to calculate dimensions and operating conditions of small-scale flash dryer (based on Excel sheet)	Delivered
	Training Material (AT)	Tool to calculate business plan for investment in a small-scale flash dryer	Delivered
	Report (AT)	Surveys of the technical expertise of the equipment manufacturers in DRC and Nigeria	Delivered
	Report (AT)	Technical support activities	Delivered
	Video (AT)	Interviews to the participants during the training sessions.	Delivered
3. Handbook of quality standards for flash-dried cassava starch and flour, including methods of assessment	Manual (AT)	Handbook of quality standards for flash-dried	Delivered
4. Business plans and models for investment in flash drying according to three to four scenarios taking into account: construction of new dryer or modification of existing dryer; adaptation of dryers for different production capacities; types of energy and quantities of cassava locally available	Template (AT)	Business plans calculation tool (Excel)	Delivered
5. Organizational models for creating enabling conditions for adoption of small-scale flash drying technology at factory level and value chain	Report (AT)	Documentation of the management of initiatives as Organizational models	Delivered

level (cassava producers, institutional environment, access to capital, etc.)			
6. Geo-referenced equipment manufacturers, cassava processors and cassava producers at country level and regional level	Map (AT)	Maps of DR Congo, Nigeria, Colombia+ Excel database with the geo-referenced equipment manufacturers and cassava processors	Delivered
	Map (AT)	Maps with geo-referenced + Excel database of cassava producers	Delivered
7. Scaling readiness approach documented	Report (TT)	Intervention profile has been completed and is documented	Delivered
	Report (TT)	Innovation profile has been completed and is documented	Delivered
	Report (TT)	Stakeholder profile has been completed and is documented	Delivered
	Report (TT)	Diagnosis survey has been completed with at least 30 stakeholders and analysis of the results is documented including at least 80% of the key innovation components identified in the surveys	Delivered
	Report (TT)	Innovation package described with core and complementary components clearly identified	Delivered
	Report (TT)	Theory of scaling workshop has been conducted with a number of stakeholders that is representative of the diversity identified in the stakeholder profiles and is documented	Delivered
	Report (TT)	Theory of scaling document produced using the suggested format	Delivered
	Report (TT)	6-month reflection and learning reports produced and adjustment in plan of work and/or scaling strategy documented	Delivered
	Template (AT)	Scaling readiness vs. Innovation use assessment	Delivered

Once you have reported the deliverables under the project created in MEL. You may generate this information directly through the POWB page.

Annex 1. Stakeholders meeting Program

Stakeholders meeting – Friday 29 November 2019
"Scaling up of an Energy Efficient Flash Dryer at Small Scale Project"
FIIRO, Lagos, 10:00am to 1:00pm
Proposed Program

#	Time	Agenda	Facilitator for each activity
1	10:00 – 10:15	Opening of the meeting Introductory remarks	Dr W.B. Asiru Dr A. Abass
2	10:15 – 10:45	Presentation flash drying technology Overview of the energy efficiency project Comparison of current situation and upgraded situation Recommended upgrades: Pipe length, heat exchanger	Dr A. Chapuis Dr T. Tran
3	10:45 – 11:15	Innovation components and barriers to adoption	Dr A. Taborda Dr E. Totin
4	11:15 – 11:45	Open floor: Discussion Responses by: NIRSAL, CBN, BOA, BOI, First Bank, Zenith Bank, Quality Control, ICSAN, NCAPMA	Dr O. Makuachukwu Eng. S. Adegbite
5	11:45 – 12:15	Roundtables: Group work What is the viability of flash drying technology for HQCF, in terms of: Technical aspects; market access; policy environment	Dr E. Totin
5	12:15 – 13:00	Stakeholders questionnaire	Dr E. Totin Dr A. Taborda
6	13:00	Closing the meeting & lunch Stakeholders forum on flash drying and cassava processing to be held in 2020	Dr T. Tran