Bern University of Applied Sciences

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Cost Benefit Analysis of the Grain Postharvest Loss Prevention Project, Dodoma, Tanzania

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Implemented by

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HELVETAS Swiss Intercooperation

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Abbreviations

AC	Acres
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
DAI	Development Alternatives Inc. (US consultants' company)
EW	Extension workers
GPLP	Grain Postharvest Loss Prevention
HH	Households
HSI	Helvetas Swiss Intercooperation
IRR	Internal Rate of Return
M&E	Monitoring and evaluation
M4P	Making markets work for the poor
MSD	Market System Development approach
NPV	Net Present Value
OPV	Open Pollinated Variety
PHM	postharvest management
PHP	postharvest practices
PHT	postharvest technologies
PICS	Purdue Improved Crop Storage (bags)
SDC	Swiss Agency for Development and Cooperation

Executive summary

The present study is based on the data collected during a field visit in Dodoma and the project area in June 2017. The author visited a limited number of farm communities within the project area, as well as other important stakeholders such as artisan and agrodealers.

The objective of the study was to conduct a cost benefit analysis (CBA) for different postharvest market actors in the postharvest market systems promoted by the GPLP in the Central Corridor of Tanzania. The project is currently reaching the end of its first phase, preparing the second project phase.

In this study, we have analysed the costs and benefits at four levels:

1. First at the **farmers'** level looking at the costs and the benefits of improved post-harvest management of maize. This analysis is based on an "average farmer" from the project area, with a total farm size of 2ha (5ac), and a maize area of 1.8ha (4.5ac). The maize yield considered is 1'500kg/ha (600kg/ac). For this "average farmer" adopting the improved PHM (consisting of 1 500kg metal silo, PICS bags and PP bags + chemicals) is highly profitable: Net Present Value (at 12% discount rate) is positive (1'075'600 TZS) and the Internal Rate of Return is high with 102.1%.
2. At the level of the **artisans** involved in the production of metal silos, we have also sketched a "standard artisan" producing an increasing number of silos in the project area. For this "standard artisan" producing about 500 silos per year, the CBA shows a positive result: NPV (12%) = 25'657'926 and IRR = 205% assuming that the artisan produces and sells 30% of the silos directly to farmers, while for the remaining 70% he produces them on commission for an agrodealer (in which case he is only paid for the labour time).
3. The **agrodealers** are important stakeholders in the rural areas as main suppliers of seeds and fertilisers to the farmers. Their task in the PHT value chain is to disseminate the technologies to the farmers. They have another important function in the PHT value chain: they pre-finance the supplies for the construction of metal silos by the local artisans. For the "standard agrodealer", the PHT business is also profitable. The analysis for agrodealers shows that they are dealing with large volumes of PHTs with a relatively small margin. This is reflected in the CBA results: NPV (12%) = 45'581'309TZS and IRR = 29.6%.
4. After these analyses for individual "standard" stakeholders, the next analysis level encompasses the **project as a whole**, including all the project costs. This was done in two steps, first without the management costs, and then with those costs.
   This analysis required making assumptions on the adoption of technologies at the scale of the project. This was done without having solid information from the field (there is currently a study on adoption of PHTs going on in Dodoma, the results of which should be available by the end of 2017[1]). Three scenarios have been sketched for this analysis, namely a "base scenario" where the total number of "average farmers" adopting the PHM reaches 40'000 by 2021, an "optimistic scenario" where the number of farmers reaches 100'000, and a "pessimistic scenario" where only 20'000 farmers adopt the PHM by 2021.
   The results of CBA4 are the following: when management costs are excluded, the NPV (12%) is positive for all three scenarios, and the IRR is respectively 42%, 29% and 19% for the optimistic, base and

[1] Mathilde Hans-Moëvi, BSc thesis at the Bern University of Applied Sciences (BFH), School of agricultural, forest and food sciences (HAFL), Zollikofen, Switzerland

pessimistic scenarios. When the management costs are included, then the NPV (12%) is only positive for the optimistic scenario, while it is negative for the other two scenarios.

The study also shows that the demand for PHTs (especially silos) is highly price elastic, which means that farmers' demand is likely to react strongly to a price change.

Based on these findings, the study recommends:

1. To further refine the analysis of the "average farmer" and to shape post-harvest strategies adapted to the different farm types and their specific needs
2. To give a high priority to boosting the demand for PHTs during the second project phase, in order to get as close as possible to the optimistic scenario; this can be achieved by several complementary measures including:
   → demonstrating the usefulness of the technology for the farmers (this was done in the awareness raising and promotion campaigns in phase 1)
   → improving the access to the technology: microfinance, payment modalities, etc.
   → reducing the price of the technology: subsidies and / or reduction of production costs
   Subsidies are justified: i) because the demand for silos seems to be highly price elastic, ii) because metal silos that are in farm households will remain there and will be used for at least the next 20 years, iii) because of the limited time left to the project (how to make the best use of the resources available in the last phase?), iv) and because the subsidies are affordable for the project (estimated at about 1.44 million $) with corresponding budgeting.
3. Continue supporting the PHT value chain to ensure the timely supply of metal silos and other technologies (while maintaining quality standards).
4. The project should not get involved directly in supporting the crop production (this is not the scope of the project) but we encourage the project to develop synergies with other stakeholders (e.g. government agricultural services, extension, other projects) to improve the maize crop (yield level and yield stability).
5. The project is encouraged to bank on the argument of food security at household level to show the value of the grain storage strategies promoted by the project. This is important in the policy dialogue with the Ministry of Agriculture.
6. The GPLP approach is well adapted to the farm sizes that we have met during the field visit (smallholders, with up to 2 ha of maize). In areas where maize production is more important, different strategies may need to be developed.

Report structure

The present report first introduces the GPLP project and the objectives of the study (chapter 1). This is followed by some methodological aspects including a brief review of similar studies done in Africa in the recent past, as well as a short explanation on how the CBA is applied in the present study (chapter 2). The main findings from the field visit in June 2017 follow in chapter 3. The findings comprise various aspects at the level of farmers, artisans and agrodealers, and also information obtained from agricultural extension officers, as well as other key informants. Chapter 4 contains the CBA model, with all the assumptions that were required for the model. The logic of the model structure is explained. The outcome of the model is discussed in chapter 5, along with the results of the sensitivity analysis. Finally, chapter 6 contains some recommendations and conclusions.

1 Introduction

1.1 GPLP background and objectives

The Terms of Reference of the present mission are summarized below, as an introduction to the present report on CBA:

"Postharvest losses of food grains in central Tanzania are high, between 15 to 40% is lost from harvest until consumption. An important factor contributing to these losses is the lack of appropriate storage facilities at household levels. Recognizing the challenges of post-harvest loss management in Tanzania, the Swiss Agency for Development and Cooperation (SDC) entrusted HELVETAS to implement the Grain Post-harvest Loss Prevention Programme (GPLP) with the overall goal of reduced post-harvest losses in food grains (mainly maize) in the Central Corridor of Tanzania.

The project pursues three main objectives:

- *smallholder farmers reduce postharvest losses and improve income by adopting better storage management practices and technologies*
- *creation of a sustainable market for metal silos produced by local tinsmiths, and alternative post-harvest technologies (input supply chains for postharvest technologies)*
- *contribute to improved postharvest policies and framework conditions in Tanzania.*

*The project uses the **"Market System Development (MSD) approach"**, strategically guided by four underlying principles: i) systemic action in market system, ii) sustainable change by involving actors with incentives to contribute to long-term change, iii) large-scale impact on the lives of poorer farmers and iv) taking a facilitative role.*

The project works towards achieving these outcomes through five clusters that correspond to the project outputs:

1. *A solid multi-stakeholder platform is in place and functioning,*
2. *Awareness building, communication and training of farmers on PHM practices and technologies is effective,*
3. *Coaching of artisans in manufacturing and marketing of metal silos is successful,*
4. *Market development and access to financial services for PHT are effectively facilitated,*
5. *Action research, monitoring and knowledge management is effectively conducted.*

The project aims to bring in behaviour change of smallholder farmers by adoption of improved postharvest management technologies and practices (PHT) including adoption of storage technologies at the *household level. The project in partnership with actors of the PHT supply chain (artisan, agro-dealers and their agents) is promoting different types of PHT.*

The GPLP project was designed as a long-term intervention that would run for eight years, divided into two phases with a 14 months' inception phase. The project is currently concluding its first full phase (11.2014 – 10.2017) and a next four-year phase 2018-2021 is under planning.

Both SDC and Helvetas-Swiss Intercooperation are interested in the effectiveness of their interventions. These Terms of Reference present the purpose, scope and requirements of a cost-benefits analysis (both financial and economic analysis) for the postharvest interventions of the GPLP project that is an important input for the planning of the second phase.

1.2 Why a cost-benefit analysis of the GPLP?

"The overall objective is to conduct an ex-post Phase I (ex-ante phase II) cost benefit analysis (CBA) of the GPLP project.

Specific objectives of the CBA are:

- to conduct cost benefit analysis of different postharvest markets actors in the postharvest market system[2] *to conduct an economic analysis of the GPLP project intervention*

The first objective will contribute to compare and identify the most effective storage technologies at the level of smallholder farmers to benefit from safely stored grain (in terms of enhanced household consumption and sales of grain later in the season when prices are higher).

The second objective will contribute to know overall benefits and potential long-term impact of the project."

Specific tasks and deliverables of the mandate are listed in annex 1.

2 Methodology

The field visit related to this mandate took place from June 11th until 24th 2017. As an intern from HAFL – Mathilde Hans-Moëvi – is working with GPLP in Dodoma on the adoption of postharvest management practices and technologies in the GPLP, the supervision of the student was combined with the CBA mandate.

2.1 Cost benefit analyses in the postharvest sector

Cost benefit analyses have been conducted in various postharvest management projects in Africa in the past few years. Some of these studies were done within the framework of SDC funded projects, but also other analyses exist:

- FANRPAN: Cost Benefit Analysis of Post-Harvest Management Innovations in Mozambique; March 2017**,** Munhamo Chisvo (CBA Economist), Ellen Jaka (Research Assistant), Jimat development consultants

[2] The previous objectives "to *conduct an analysis for selected postharvest technologies at the farmer's level that have been promoted by the project (Metal silo, PICS bags, ordinary PP bags with/without actelic treatment)" was changed to* "cost benefit analysis of different postharvest markets actors in the postharvest market system" (see section 2.2 for justification)

- Cost Benefit Analysis of Post-Harvest Management Innovations, Benin Case Study, Draft Report, March 2017, Munhamo Chisvo (CBA Economist), Ellen Jaka (Assistant Researcher), Jimat development consultants
- Cost Benefit Analysis (CBA) Report, Maize Storage Project, DAI consultants, August 2013 (with SDC funded project that operated in Malawi, Zimbabwe, Kenya and Zambia).
- Cost benefit analysis of maize production and marketing in Uganda, Leonard Leung and Glenn P. Jenkins, Queen's University, Kingston, Canada, 2012
- Scaling adoption of hermetic postharvest storage technologies in Uganda, Massachusetts Institute of Technology, Cambridge, Massachusetts, Universidad del Rosario, Bogotá, Colombia, and Gordon College, Wenhem, Massachusetts, 2017

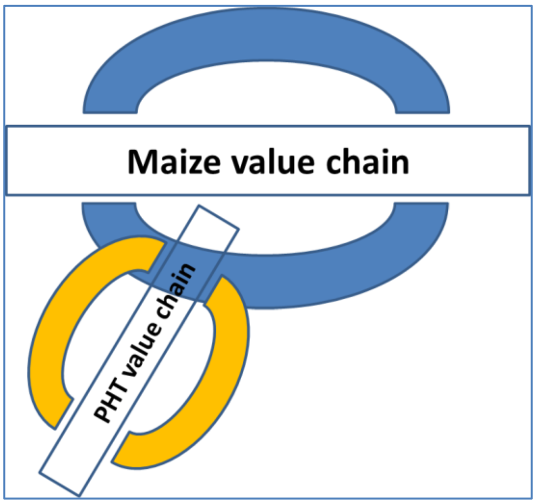
Most of these analyses focus on the analysis and comparison of the costs and the benefits of the different postharvest technologies at farmers' level, while considering different farm sizes and levels of maize (or other food grains) production.

2.2 GPLP internal workshop in Dodoma

In our understanding, the Cost Benefit Analysis of the GPLP was meant to have a slightly different focus, as an important aspect of this project concerns the M4P approach applied to the market of the PH technologies. This was discussed in an internal workshop in Dodoma, on June 12th. The outcome of the workshop highlighted the following specific interests of GPLP:

- financial CBA at farmers' level looking at the profitability of postharvest technologies as well as practices (CBA1)
- financial CBA at the level of artisans involved in the manufacture of metal silos for grain storage (CBA2)
- financial CBA at the level of agrodealers who are disseminating the postharvest technologies as one of their activities (CBA3)
- overall economic CBA looking at the profitability of the GPLP intervention (CBA4).

Cost Benefit Analysis of specific postharvest technology and practices are available in the above-mentioned studies. In actual practice, a farming household uses a combination of several postharvest technologies and practices and not only a single one. With the limitation of time to collect data for CBA at the household level and other ongoing studies, this study focusses on the cost benefit analysis of different postharvest markets actors in the postharvest market system. However, an ongoing study carried out by an HAFL intern on adoption of postharvest technologies and practices will analyse the cost benefits of different PHT and PHP at the household level.



2.3 Value chain, M4P / MSD

The GPLP project is touching two value chains that are intertwined, as illustrated in figure 1. The project objective does however not directly address maize production or the maize value chain. The M4P/MSD approach, which is mentioned in the project document, is therefore applied – as much as possible – to the PHT value chain, in which the artisans are the main actors (they produce the silos), the agrodealers are involved in various ways (e.g. supplying metal sheets and other raw materials for the silos) and the farmers are the clients.

In terms of stakeholders, the artisans and the agrodealers create their value added in the PHT value chain, while the farmers generate their value added in the maize value chain. The CBA will show where more value is added in that system.

Figure 1 Maize value chain and PHT value chain

3 Findings

3.1 Farmers

The mind map (figure 2) shows that we did not only ask farmers about their post-harvest practices, because it is important to have a clear picture of the maize production potentials and constraints to fully understand the farmers' strategy and decisions about PHM.

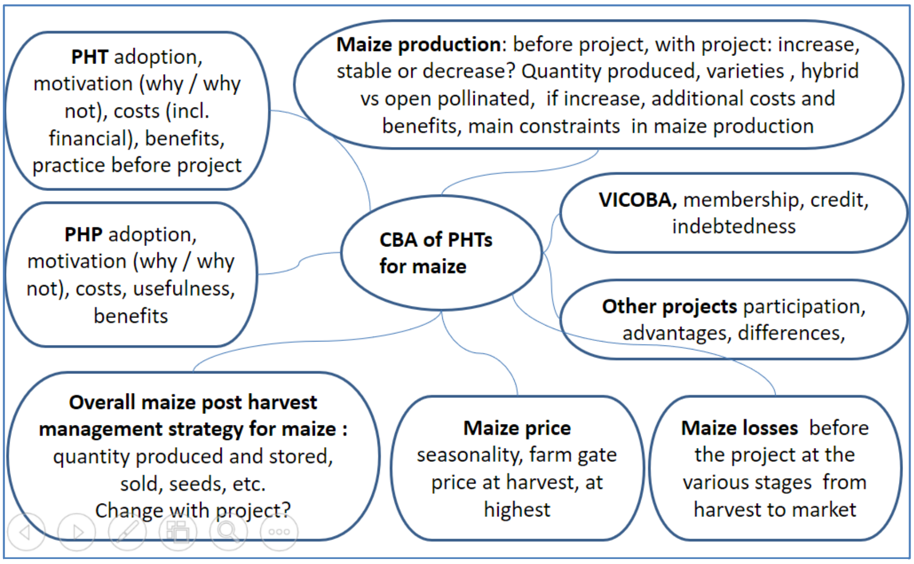


Figure 2 Mind map for interviews with farmers' groups

Maize production, farm size

Maize is the main staple crop in the communities that we visited, except in Mnenya where finger millet and sorghum are more important than maize. Maize is very often intercropped with pigeon pea.

On average, the farmers have a crop area of less than 5 ac, out of which 2 to 3 ac are cultivated with maize (or other staple grain crop like finger millet or sorghum).

Maize is mostly grown without irrigation, without mineral fertilizer, but with variable amounts of FYM.

Maize harvest was mentioned to reach 15 bags per ac (or even more in favourable years), but in 2017, due to draught, they expect a very poor yield, in some cases even nothing at all (Dirma in Hanang District).

Maize varieties

Farmers grow both hybrid and open pollinated varieties of maize. Mostly the seed is bought from the agrodealers, but some farmers also keep their own seed. The main characteristics of maize varieties are: white grain, early maturing, drought tolerant, high yielding. The varieties available in the Agrodealer shops are the following / from the following origins:

Seed company	Origin	Comments / variety
Seed Co	Zimbabwe	Hybrid varieties of white maize
IFFA seeds	Tanzania	Variety Stuka M1, OPV

Pannar Seeds	South Africa	Ultra-early maturity (95-100 days), hybrid
Du Pont	USA	Pioneer, hybrid varieties
Meru Agro	Tanzania	Early maturing, drought tolerant, hybrid
Monsanto	USA	Dekalb, hybrid (named DK in the project area)

Losses of grains after harvest

It is difficult to assess the losses after harvest; nevertheless, when farmers were asked what are their main problems with maize production, they mentioned:

- Draught: apparently, this is a recurrent problem, and it is particularly acute in 2017
- Diseases and pests: during plant growth, several diseases and pests are damaging the crop
- Losses at harvest and after harvest: this is partly due to pests and diseases as well, including rodents.

Farmers' statements about losses: "Losses occur already at harvest, before the maize is dried and stored. In the store, rodents are a serious problem, as well as insects and fungi. Losses can be 100% if storage is done in PP bags without chemical treatment."

Maize post-harvest practices and technologies

The farmers we met are mostly aware of the issue of post-harvest management of their maize crop, and related practices (harvest with tarpaulin, secured transport, shelling with machine, drying with tarpaulin, cleaning, etc.).

The technologies promoted by the project (PP bags + chemicals, PICS bags and metal silos) are also known by the farmers (at least by those who participated in training sessions of the project). The metal silo is unanimously considered the best technology, because it protects the maize also against rodents, which is not the case of the other technologies.

Overall, the rate of adoption of the post-harvest management technologies and practices remains low, mostly due to the costs of the technologies (especially PICS bags and metal silos). A specific study on the adoption of these practices and technologies is currently being conducted by Mathilde Hans Moëvi in her BSc thesis.

Metal silo: willingness to pay

During the meetings with farmers, we asked them what they would consider an acceptable price for the metal silo (compared to the current price of 230'000 TZS), taking the example of the 500kg model.

- Nobody said that the silos should be free!
- Most farmers mentioned prices comprised between 100'000 and 160'000 TZS.

Based on the farmers' answers, we attempted to draw a demand curve for metal silos (figure 3). This is an interesting result showing that for a price of about 150'000 TZS, almost 80% of the farmers would buy a

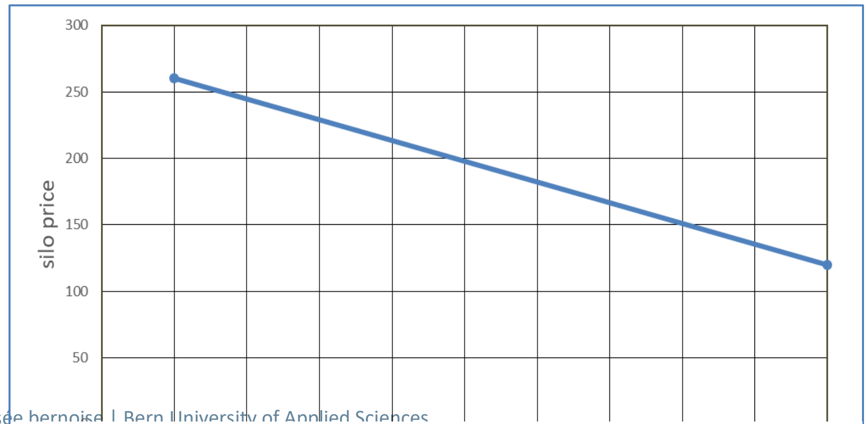


Figure 3 Willingness to pay for metal silos: the demand curve (based on approx. 50 farmers' statements)

silo. The PICS bags were sold at a price of 5’000 TZS in 2016, and the price was reduced to 4’500 TZS in 2017. Besides the price of silos, farmers are also interested to pay in instalments, or to pay at least part of the price in kind (e.g. maize).

Farmers’ strategy: combining PHTs

The depicted strategy may not precisely reflect what farmers are doing now with the PHTs, but based on their answers, it is likely that they will move towards a combined solution in the future:

a) Metal silos for own consumption

Clearly, metal silos are used for securing the food of the household, not for speculation on the price. Those farmers who already own a silo are proud of it, and obviously, they take great care of their silo.

In my opinion, the role of the silo for smallholder farmers in the Central Corridor of Tanzania can be compared to the role of the refrigerator in an urban household.

b) PICS bags are considered as the second-best option

They are used for own consumption or for marketing. Usually, if farmers sell maize from the PICS bag, either they add the price of the bag to the buyer or they transfer the maize in normal PP bags.

c) PP bags with chemicals for those who cannot afford more

Chemicals are important for keeping maize in the store. Without chemical in the PP bags, it is likely that 100% will be lost.

Combining PH technologies

In the future, it is very likely that the PH technologies will be combined at farm level, therefore the CBA calculated at the level of farmers is calculated for a combination of PHTs.

Average maize farmer

For the CBA, we defined an “average maize farmer” for whom the analysis will be done. The data is partly taken from the baseline survey, while we did some adjustments based on the farmers we have met during the mission. All the parameters with a yellow background can be modified in the Excel model, as it will be explained in the next chapter.

This “average maize farmer” is based on many assumptions as it appears in figure 4.

Average farm household characteristics					**Important figures for the calculations**	
members		5.00			maize production costs (TZS/ac)	120 000
farm area (ac)		5.00			maize needs per capita/ year (kg)	73
maize area (ac)		4.50			number of metal silos (500kg)	1
maize production per hh (kg)		2 700			price of metal silo (500kg) (TZS)	230 000
pulses production per hh (kg)		800			metal silo lifespan (years)	20
Number of farmers					price of PICS bags (TZS)	4 500
	trained by project total				PICS bags lifespan (years)	3
	in project wards total				price of chemicals for PP bags, per bag (TZS)	1 000
	in project regions total				tarpaulin (TZS)	30 000
					tarpaulin lifespan (years)	3
Benefits with improved PHM					improved PH practices per year	20 000
PH losses without the project		17%			interest rate VICOBA (per year)	20%
PH losses with the project		7%				
maize price lowest (TZS/kg)		400			**CBA1 results in a nutshell**	
maize price highest (TZS/kg)		600			NPV	1 075 600
pulses price at harvest (TZS/kg)		900			IRR	102.07%
					BCR	2.57
Financial plan metal silo		**year 0**	**year 1**	**year 2**		
	credit from VICOBA	230 000				
	instalment 1 + 2		115 000	115 000		
	interest		46 000	23 000		
Yield	maize yield (kg/ac)	**600**				
	maize yield (kg/ha)	**1 500**				

Figure 4 Average maize farmer in the Central Corridor of Tanzania

Business model for farmers

The assumed "average farmer" producing 2.7 Mt of maize will buy one silo (500kg) and he/she will need 12 PICS bags to store the maize. 30% of the production will be sold immediately at harvest time (727kg). The remaining maize (1'197kg) will be stored until the price increases to its highest level. The number of PICS bags can be lower if the farmer uses PP bags with chemicals, but we did not want to make the business model too complicated (figure 5).

Maize strategy per farmer		
Average farmer	**without project**	**with project**
Staple crops production		
total maize (kg)	2 700	2 700
total pulses (kg)	800	800
Post harvest losses - MAIZE		
maize available after losses (kg)	2 241	2 511
maize lost (kg)	459	189
Maize use		
own consumption (kg)	365	365
available for sale (kg)	1 876	2 146
sale at harvest	100%	30%
sale at highest price	0%	70%
Pulses use		
own consumption %	20%	20%
sale at harvest time %	80%	80%
pulses available for sale (kg)	640	640

Financial results	**without project**	**with project**
Value of own maize (TZS)	146 000	146 000
Revenue maize sales (TZS)	750 400	1 158 840
Value of own pulses (TZS)	144 000	144 000
Revenue pulses sales (TZS)	576 000	576 000
TOTAL VALUE MAIZE and PULSES	**1 616 400**	**2 024 840**
Production costs (TZS)	540 000	540 000
GROSS MARGIN maize + pulses (TZS)	**1 076 400**	**1 484 840**
Gain with improved PHM (per year)		**408 440**
Costs of improved PHM / year		
tarpaulin (annual costs)		10 000
improved PH practices (annual costs)		20 000
metal silo 500kg (annual costs)		11 500
cost of capital (interest annualized)		3 450
number of PICS bags required		12
PICS bags for delayed sale (annual cost)		17 850
Additional costs for PHM		**62 800**
ADDITIONAL BENEFIT WITH IMPROVED PHM (per year)		**345 640**

Figure 5 Business model - farmers

The additional benefit with improved PHM (per year) from figure 5 is calculated to give an idea of the advantage of the improved system for the average household. However, this amount is not used in the CBA calculation where actual costs and benefits are computed when they occur in time and not annualized.

3.2 Artisans

For the interviews of 3 artisans, we used the following mind map (figure 6) that lists the relevant topics we wanted to discuss with them.

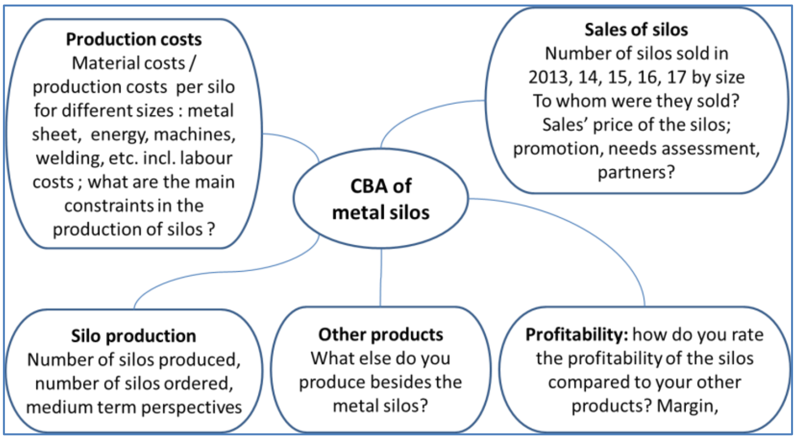


Figure 6 Mind map - artisans

Background of the artisans

Of the three artisans met, one was carpenter and welder, while the other two were mainly involved in welding as their main activity.

In their welding activity, they deal mainly with doors, gates and windows, as well as repairs of machines, cars, etc. For all three artisans, the production of silos is a seasonal activity, but it is by far not their main activity. This may change with a sharp rise of the demand for metal silos.

Start of silo production

Two artisans started silo production in 2015 while the third one started in 2016. They were trained during 5 days by the project, and this was followed up with coaching on the spot. One artisan stated that initially he thought that producing silos would be difficult, but after the training, he said that it is fairly simple.

Of the three artisans met, only one has initiated a real business with the silos (in Mnenya). The other two are still waiting. The fact that they are not yet producing silos as a business explains why they use more raw materials for 1 silo. With enough experience, manufacturing silos can be optimized.

Production of silos - general information

	Artisan 1	Artisan 2	Artisan 3
Location	Mnenya	Dirma	Kissese
Start activities	2015	2016	2015
Silos produced so far:			
→ 2015	< 10	0	10
→ 2016	90 – 100	7	10
→ 2017	13 (first orders)	?	?
Production costs for a 500kg silo			
→ Metal sheets	2.1	2.5	2
→ Soldering sticks	1.5 small or < 1 big	3 small	2 small
→ Acid	Small quantity	Small quantity	Small quantity
→ Labour	Upto 13 silos in 2 days with 2 helpers	One silo in 2 days, with 2 helpers	One silo in 2 days, with 2 helpers
Sales of silos	Agro-dealer and directly to farmers		

Figure 7 Key figures from 3 artisans

The poor maize yield in 2017 may act negatively on the demand for silos this year, which in turn will reduce the income of artisans.

Production of silos – production costs for 500kg silos

		Artisan 1	Artisan 2	Artisan 3
Location		Mnenya	Dirma	Kissese
Metal sheets	TZS / silo	115’500	137’500	110’000
Soldering sticks	TZS / silo	36’000	60’000	48’000
Acid	TZS / silo	2’500	2’500	2’000
Labour (hired)	TZS / silo	5’000	10’000	10’000
TOTAL	TZS / silo	**159’000**	**210’000**	**170’000**

Figure 8 Production costs of the 500kg metal silo

As already mentioned, the more professional artisan (artisan 1) could reduce his production costs compared to the two others. We can assume that with increasing demand for silos, the artisans manufacturing larger numbers of silos will have production costs close to those of artisan 1.

Business model for artisans

For the calculation of the specific CBA, we sketched a “standard artisan”. In this case however, we were a bit optimistic, in the sense that we looked at the most advanced artisan, and looked also into the future.

Therefore, the “standard artisan” may appear too advanced for the present situation, but we believe that it is a realistic projection for the future.

As shown in figure 9 the standard artisan should gradually increase the production to almost 500 silos per year, which assumes of course an increasing demand from farmers. In the table, the boxes with a yellow background can be modified by the user of the Excel model.

Production of silos over 6 years							
Plan of production	***year 0***	***year 1***	***year 2***	***year 3***	***year 4***	***year 5***	***year 6***
Production of silos		2 015	2 016	2 017	2 018	2 019	2 020
number (250kg)		5	30	40	50	50	50
number (500kg)		5	60	150	300	300	300
number (1000kg)		0	8	60	100	100	100
number (2000kg)		0	2	10	20	20	20
TOTAL number of silos		**10**	**100**	**260**	**470**	**470**	**470**

Figure 9 Business model for artisans

3.3 Agrodealers

The agrodealers are important stakeholders in this value chain, for various reasons. We could interview 2 agrodealers during the field visit, and these meetings proved to be very interesting. The following mind map was used to guide our interviews (figure 9). The two agrodealers we met are Grace Mpoli from Babati and Mringo Vet Agrofrom Kondoa.

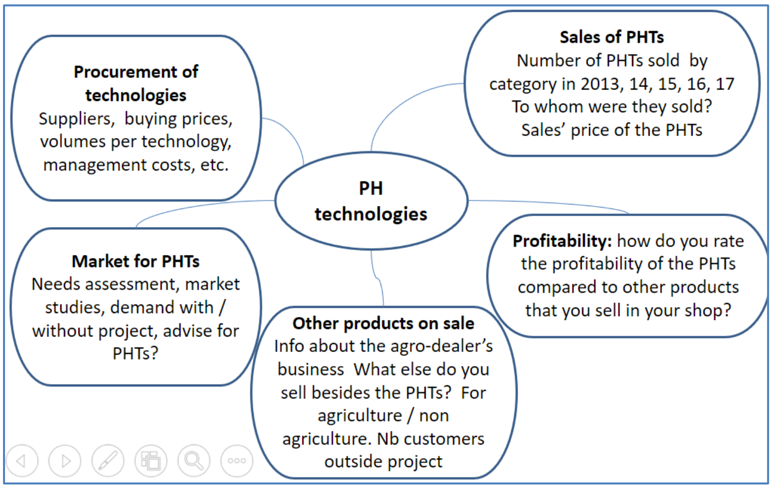


Figure 10 Mind map for agrodealers

Grace Mpoli in Babati is operating as an agrodealer since 2008. Over time, she developed her business and her capital. Besides agricultural inputs, she is also dealing with food and clothes. She has 3 employees. At the moment, fish is her major business. Agrovet activities are seasonal, and post-harvest technologies represent only a small share of her turnover.

For the metal silos, she cooperates with artisans in the district by providing them the necessary inputs. Then the artisans either buy the metal sheets, soldering sticks, etc. to the agrodealer or they produce the silos on commission. In that case, the artisans are only paid for their labour, per silo.

To facilitate the access of farmers to the PHT – especially to the metal silos – she has introduced a system with 50% payment at delivery and 50% as instalments.

Mringo Vet Agro in Kondoa started the agrodealer activities in 2002. Besides agricultural inputs, he deals also with hardware and construction materials. He has 4 employees and 2 locations outside Kondoa, namely Mnaruni and Chemchem. Overall, the agricultural inputs represent 75% of the turnover of Mringo. Within this section, seeds represent 65%, fertilizers and vet drugs about 15% each. He also sells some equipment for irrigation, as well as small hand tools but no large equipment.

The PHTs have been introduced with the project. He thinks that PHTs have a real potential for the farmers (but also for him) therefore he is increasingly active in this field.

He is cooperating closely with the artisan from Mnenya to whom he supplies the inputs to produce metal silos (ref CBA2 artisans, model 2).

Sales of PHTs

Both agrodealers informed about their sales of PHTs, but they could not provide details about the storage chemicals sold for the PP bags.

		Mpoli	**Mringo**
Location		Babati	Kondoa
Start activities		2008	2002
Sales of PICS bags	→ 2015 → 2016 → 2017	? 2800 2000*	1200 4744 6000*
Margin on PICS bags (estimated, average)		500 TZS	700 TZS
Sales of metal silos	→ 2015 → 2016 → 2017	? 37 12** / ?***	391 5**/ 300***

** estimated. Mpoli mentioned that die to the poor harvest in 2017, there will be no increasing demand for PICS bags ** orders*
**** estimated, for the whole year*

Figure 11 Sales of two agrodealers in the project area since 2015

Similarly, as we did for the farmers and artisans, we also tried to sketch the "average agrodealer" in the project area. In chapter 4, the cost benefit analysis of this average agrodealer will be calculated. This will answer the question of the profitability – from the agrodealers' perspective – of the business of disseminating PHT in the farmers' community.

Business model for the agrodealers

Business planning over 6 years

Sales of	***year 0***	***year 1***	***year 2***	***year 3***	***year 4***	***year 5***	***year 6***
PICS bags - nb		1 200	4 500	6 000	10 000	10 000	10 000
Metal silos (in commission) - nb		30	390	400	600	600	600
Chemical for PP bags (bottles, 1 bottle for 4 bags)		?	?	3 000	5 000	5 000	5 000

Note 1: for the silos, as it is difficult to predict which size will be the most demanded and produced one, we do not distinguish between sizes, and take the 500kg silo as a reference.
Note 2: we assume that the numbe of PP bags will be the double of the PICS bags, and accordingly that the chemicals (1 bottle for 4 PP bags) will be half the number of the PICS bags

Figure 12 Business model for the agrodealers

Here also we assumed an agrodealer oriented towards the future with increasing sales compared to the present situation. The assumptions made for the agrodealers are shown in figure 13.

Key assumptions and base information

Summary information for the agrodealers		
Discount rate		12%
Sales' price metal silo, average per silo	*TZS/silo*	260 000
Supplies for silo production, average per silo	*TZS/silo*	135 000
Manufacturing charge, average per silo	*TZS/silo*	30 000
Buying price PICS bags	*TZS/bag*	3 800
Sales' price PICS bags	*TZS/bag*	4 500
Buying price PP bags	*TZS/bag*	400
Sales' price PP bags	*TZS/bag*	700
Buying price chemicals for PP bags (1 bottle -> 4 bags)	*TZS/bottle*	2 800
Sales' price chemicals for PP bags (1 bottle -> 4 bags)	*TZS/bottle*	4 000
Share of own capital	*%*	50%
Interest rate on borrowed capital	%	12%
Taxes (TRA / VAT, etc.)	% on profit	30%

Figure 13 Assumptions agrodealers

3.4 Entire project

In this section, we introduce some key figures about the project in terms of outreach and stakeholders. The figures were provided by the project management.

3.4.1 Number of farm households

The number of farmers reached by the project is indicated in the next table.

Number of farm households (2014 - 2016)	Morogoro	Dodoma	Shinyanga	Manyara	TOTAL
trained by project total (2014-16)	5 523	7 910	4 606	8 089	26 128
in project wards total	47 393	39 984	38 695	40 325	166 397
in project regions total	443 698	416 718	306 962	285 026	1 452 404

26’128 farmers (representing as many households) have been trained by the project between 2014 and 2016. The training was on raising awareness of the farmers about the issue of post-harvest losses and their mitigation. The table also shows the total number of farm households in the wards where the project operates, as well as the total number of farm households in the project regions. The latter figures give an idea of the potential for the project to expand, and the potential demand for silos and PICS bags in the 4 regions.

3.4.2 Number of artisans

So far, the project has trained artisans in each ward where the project operates. The number of artisans that will be required in the project area will depend on two major factors: the demand for silos (from project farmers as well as non-project farmers and other stakeholders), and the production capacity of the artisans.

The demand for silos will depend on the maize harvest (farmers are not likely to buy silos after a very poor harvest like in 2017 in some wards), on the farmers’ storage strategy (combining silos, PICS bags and PP bags + chemicals) and it will of course also depend on the silo prices, assuming a rather elastic demand (as for luxury commodities).

For the model calculation, it does not really matter whether the silos are produced by many or few artisans, assuming the prices and margins remain the same: in other words, it will not make a difference to the model if 1’000 silos have been produced by 2, 10 or 20 artisans.

3.4.3 Number of agrodealers

The agrodealers involved in the project are not many so far. As explained above, their role is to disseminate the PH technologies, especially silos, PICS bags, but also PP bags and chemicals. For the model, we will assume a certain share of silos sold directly by the artisans and silos sold through the agrodealers, and we will also assume the number of PICS bags bought by the farmers to be sold exclusively by the agrodealers. For the PP bags and chemicals, we assumed that the number of PP bags would be the double compared to PICS bags. In reality, the number of PP bags and chemicals could be derived from the other two: if a farmer having 3’000 kg of maize decides to buy one silo (500kg) and 10 PICS bags, this will mean that by default, the remaining quantity of maize will be stored in PP bags (and mostly sold immediately):

2’500 kg to be stored	1 silo (500kg)	500kg	Storage for own consumption
	15 PICS bags (100kg)	1’500 kg	Storage for later sale (70%)
	5 PP bags (100kg)	500kg	Packing material for immediate sale (30%)

Here again, the number of agrodealers does not really matter (for the results of the model), more relevant is the number of bags and the margin on the bags that matters.

4 CBA model

In this chapter, the CBA model is explained, going through the steps of the method as described in the interactive tool[3]. Then the results for each component are displayed and discussed, starting with the CBA for farmers (CBA1), followed by the CBA for artisans (CBA2), then CBA for agrodealers (CBA3), and finally the overall CBA at project level (CBA4).

Step 1 Boundaries of the CBA analysis

Step 1 of the cost benefit analysis consists in analysing the boundaries of the project to be analysed. In the case of the GPLP, the boundaries to be considered are the 4 regions where the project operates, which includes the farmers living and producing maize in this area, the artisans manufacturing the silos as well as the agrodealers disseminating the PH technologies.

Step 2 Impact hypotheses

Figure 1 illustrates the result of the discussion during the workshop. At the level of outcomes, in CBA1, farmers adopt PHTs and PHPs, which will improve their situation regarding the availability and value of grains stored, which will contribute to reduced poverty and increased food security in the project areas. For the artisans (CBA2) the outcome will be locally produced silos for grain storage made available to farmers at a competitive price, which contributes to the economic development in the project area. Finally, the outcome of CBA3 (at the level of agrodealers) is that PHTs are available locally at competitive prices, which also contributes to economic development. Overall, the project is expected to have an impact on poverty, food security and economic development in the project area and beyond.

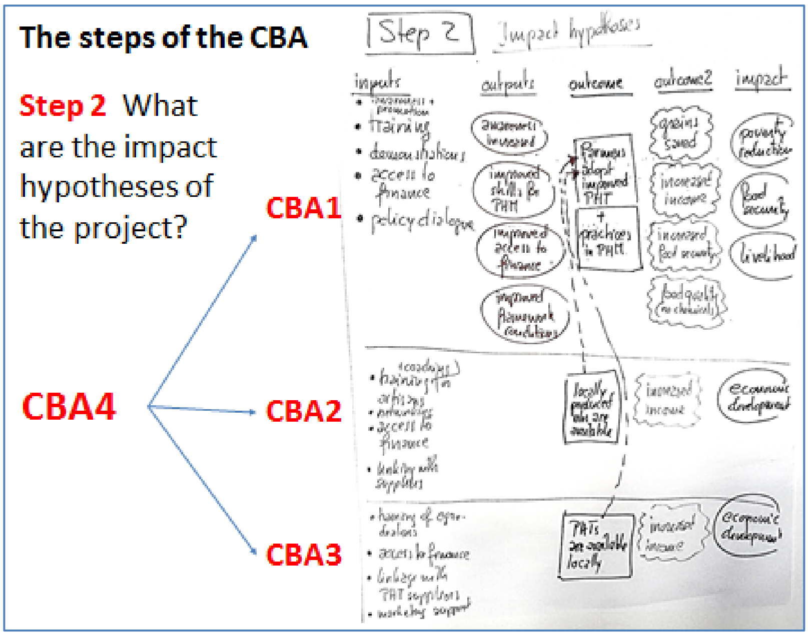


Figure 14 Impact chain of the GPLP as discussed during the workshop

Step 3a List all costs

The costs that should be integrated in the CBA are the additional costs paid by the project stakeholders (project itself, farmers, artisans, agrodealers, government, local authorities, etc.) that are necessary to achieve the expected benefits.

During the internal workshop, we have listed these costs for each category of stakeholders:

[3] http://deza-pcmi-lernbuch-3.prod2.lernetz.ch/module-6-en

1. Farmers' costs

Costs of the PH Practices	Cost of the PH Technologies
Tarpaulin	a) Cost of metal silo
Costs of threshing / shelling	b) Cost of PICS bags
Costs of cleaning (sieve)	c) Costs of PP + chemicals
Additional transport costs	Labour costs for each technology
Additional labour costs	Financial costs

2. Artisans' costs

Costs of silo production
Metal sheets
Soldering sticks
Acid
Labour
Transport
Marketing
Interests (financial costs)
Tool box

3. Agrodealers' costs

Costs of PHT dissemination
Buying metal silos from artisans
Paying artisans for silo manufacture
Buying PICS bags from suppliers
Buying PP bags from suppliers
Buying chemicals for grain treatment (together with PP bag)
Costs of promotion
Costs of distribution
Financial costs
Buying metal sheets and other inputs for silo production

4. Project costs / other stakeholders

Costs of project and other stakeholders			
	Project costs	Government costs	Other
Awareness creation	Train EW for awareness	EW train farmers for awareness	
Training	Train EW for PHM	EW train farmers for PHM	
Promotion of PHTs	Demonstration		
Access to finance	Train trainers		VICOBA train members
Subsidies for metal silos	Seed money		
Artisans coaching	Train + coach artisans		
Teaching material	Elaboration and printing		
Policy dialogue	National platform, etc.		
	Applied research		
	Project management costs		

When analysing the costs, it is important to make sure that all the relevant costs are taken into account, while avoiding that any of the costs are double counted.

Financial vs economic analysis - COSTS

In principle, all the costs are financial costs (corresponding to market prices). If the analysis is done from a private perspective (i.e. farmers, artisans or agrodealers) then those prices (market prices) should be considered. However, the same CBAs (at farmers', artisans' or agrodealers' level) can be converted to economic analyses by converting market prices into shadow prices. This is done by analysing all the costs mentioned above and modifying them where needed[4].

[4] The following link explains how to convert: https://www.adb.org/sites/default/files/page/149401/conversion-economic-prices-oct2013.pdf

Step 3b List all benefits

In step 3b, all the project benefits need to be listed. These benefits are again listed for the different categories of project stakeholders. Note that some benefits cannot be monetised. In this case, they will be recorded in qualitative terms, but will not be considered in the CBA calculation.

Farmers

For the farmers, the benefits are the following:

- Reduced losses of grains = additional value of grains
- Higher price if the surplus grains are sold when prices are higher
- Increased food security = reduced purchase of grains in the lean season, as well as increased confidence in the future, leading to increased opportunities to engage in new activities
- For the silos, prestige in the farm community, reduced space for storage, increased safety of the grain storage (can be locked)
- For the silos and the PICS bags, better quality of the grains (no chemicals for storage) = more healthy food

Artisans

Depending on the modalities of production of silos, the benefits for the artisans are either sales of silos to farmers, or other stakeholders, or – in the case of commissioned production of silos – the payment of labour costs for silo production by agrodealers.

Agrodealers

The agrodealers are merchants, so they are not producing anything. They are buying and selling different products related to postharvest management of grains. Therefore, their benefits are

- Margin on the sales of silos to farmers, or to other buyers
- Margin on the sales of PICS bags
- Margin on the sales of PP bags with chemicals
- Margin on the inputs to produce silos
- Margin on grains in case farmers are paying the silos with grains

Overall project level

At the level of the project, the benefits are the aggregation of all the benefits attributed to the project in the entire project area:

- Additional maize available for domestic consumption (at the scale of the project area)
- Reduced food imports, increased food self-sufficiency
- Increased employment (artisans, agrodealers)
- Economic development, increased income and reduced poverty
- Value creation by the artisans and agrodealers related to PHM

Step 4 Data collection

Step 4 of the CBA consists in data collection to fill the gaps, after analysing the data availability (mostly from the project M&E). In the present study, except for a short field visit in 4 wards, where we held group meetings with farmers and interviews with some key informants, no additional data was collected.

However, we should mention that a study on adoption of post-harvest technologies and practices is going on[5]. This study will provide relevant additional information that will surely help improving the model.

Step 5 Setting up the model

The Excel model consists of different sheets that are connected, containing all the relevant information. The purpose of the model is on the one hand to calculate the results of the different CBAs, on the other hand to test the models with different assumptions (sensitivity analysis).

Step 6 Interpret the results

Each CBA presented in the subsequent chapters is discussed at its own level while a general discussion of the results if to be found in chapter 5.

4.1 CBA1 - farmers

CBA1 for the farmers is calculated for the "average farmer" that was described in figures 4 and 5. We assume that the farmer has adopted a grain storage strategy that combines metal silo, PICS bags and PP bags with chemicals.

Net present value (NPV), discount rate	**12%**	**1 075 600**
Internal Rate of Return (IRR)		**102.07%**
Discounted Benefit Cost Ratio (BCR)		**2.57**

With a highly positive NPV (calculated with a discount rate of 12%), an IRR of over 100%, and a benefit cost ratio way above 2, this is an excellent result, demonstrating that it is worthwhile for farmers to adopt the post-harvest strategy. But before we can conclude that this is always a good strategy, we should make different assumptions, thus testing the model under different circumstances. This is done in the following sensitivity analysis.

Sensitivity Analysis CBA1 - farmers			
	NPV	IRR	BCR
Maize yield			
maize yield = 600 kg/ac	1 075 600	102.07%	2.57
maize yield = 400 kg/ac	480 350	50.28%	1.74
maize yield = 250 kg/ac	38 230	14.97%	1.06
maize yield = 200 kg/ac	-106 265	3.76%	0.83
Price of maize			
highest price = 600 TZS/kg	1 075 600	102.07%	2.57
highest price = 500 TZS/kg	457 984	48.44%	1.67
highest price = 450 TZS/kg	149 177	23.63%	1.22
Subsidized silos			
silo price 230'000 TZS (500kg model)	1 075 600	102.07%	2.57
silo price 150'000 TZS (500kg model)	1 215 494	175.00%	3.35
silo price 150'000 TZS, low yield (250kg/ac)	178 124	33.13%	1.39

The analysis shows that with decreasing maize yields, the profitability is drastically reduced, and at a level of about 200 kg/ac, it becomes negative (NPV is negative, BCR is below 1). The price of maize is also an influential factor: if the price of maize rises only from 400 TZS/kg to 450 TZS/kg, then the profitability is very low (but still positive).

With subsidized silos (from 230'000 TZS to 150'000 TZS), the profitability increases significantly (from 102% to more than 175% for the IRR), and with subsidies on the silos, even with low maize yield (250kg/ac) the model remains positive.

In summary, the profitability of an improved post-harvest strategy (combining practices and technologies) Is better with high yields, with a large price gap between harvest time and peak price, and is strength-

[5] BSc thesis research by Mathilde Hans-Moëvi, HAFL student 2017

ened by subsidized sales' price of silos. The combination of technologies is a meaningful strategy for farmers, so the point is not to compare the technologies but to find the optimal combination. The annual storage costs per tonne are similar with PICS bags and metal silos (considering the lifespan of both technologies), but PICS bags are more flexible for marketing while silos are more secure for home consumption. The silo could also play a role in very bad years (extremely low yields, like in 2017 in some villages): if the harvest is not enough to fill the silo, at least it would be possible to buy maize from the market and store it safely, at a time when prices are not yet too high.

4.2 CBA2 – artisans

CBA2 for the artisans is calculated for the "standard artisan" that was described in figure 9. We assume that the artisan is focusing on silo production, making it a major activity. The model assumes that the share of silos sold directly to farmers is 25% while the remaining silos are sold through agrodealers.

Net present value (NPV), discount rate	**12%**	**25 657 926**
Internal Rate of Return (IRR)		**205.3%**
Discounted Benefit Cost Ratio (BCR)		**1.27**

For this artisan, the CBA looks good as well. The net present value is highly positive (at 12% discount rate), the IRR is over 200% and the CB ratio is clearly above 1. Let's have a look at the sensitivity analysis for a better understanding of the model:

Sensitivity Analysis CBA2 - artisans			
	NPV	**IRR**	**BCR**
base scenario (30% model 1* and 70% model 2)	25 657 926	205.31%	1.27
reduced production			
- 50% from year 3 onwards	12 771 285	147.83%	1.25
- 75% from year 3 onwards	6 287 216	105.26%	1.21
model 1 only	89 291 544	591.90%	1.36
model 2 only	4 446 720	63.60%	1.10
15% reduced sales' price (model 1)	13 307 633	130.32%	1.14
20% reduced sales' price (model 1)	9 190 869	102.02%	1.10
increased production costs (+20%)(model 1)	13 433 110	131.23%	1.13
** model 1 = artisans sell silos to farmers; model 2 artisans sell silos through agrodealers*			

Even with reduced production, the activity remains profitable for the artisans. This is good news as it is not sure that all the artisans will be able to produce as many silos as the "standard artisan" that we depicted in figure 9. Obviously, model 1 (where the artisans produce and sell the silos on their own) is more profitable for the artisans than model 2 where they produce the silos on commission for the agrodealers. However, model 2 has the advantage that the agrodealers are pre-financing the materials to produce the silos, which is crucial for the success of the operation.

Reducing the sale's price of the silos affects the artisans but not too much because we assume only 30% model 1 and 70% model 2. It is likely that agrodealers will be more affected by reduced sales' prices.

Not to forget: the profitability of this business for artisan depends on a strong and sustained demand for silos from farmers!

4.3 CBA3 – agrodealers

CBA3 for the agrodealers is based on the assumptions of figures 12 and 13. The agrodealers are in a purely commercial activity, buying and selling the PHTs. For the agrodealers, the CBA shows also positive results in the base scenario. The NPV of 45’581’309 TZS (with a discount rate of 12%) is correct, and the IRR of 29.6% is acceptable. The BCR is just above 1.

Net present value (NPV), discount rate	**12%**	**45 581 309**
Internal Rate of Return (IRR)		**29.61%**
Discounted Benefit Cost Ratio (BCR)		**1.08**

The sensitivity analysis shows that these results are not so robust: if the sales of silos increases by 50% from year 3 onwards, then the profitability increases clearly (IRR to 42%). Increasing the sales’ price of silos (by 10%) increases notably the profitability for agrodealers, while a sales’ price reduction (by 10%) reduces the profitability to a rather low level. The business is also sensitive to increasing costs of inputs for silos. Note that the PICS bags do not really change much when their sales increase by 50%. This is because the agrodealers’ margin on PICS bags is rather small. All in all, the situation of agrodealers is not a surprise, their business depends on their margins and on the sales’ volume.

Sensitivity Analysis CBA3 - agrodealers			
	NPV	IRR	BCR
base scenario	45'581'309	29.61%	1.08
+50% silos from year 3 onwards	89'714'493	42.04%	1.13
+50% PICS bags from year 3 onwards	57'059'150	33.13%	1.09
silo price up 10%	72'298'472	38.06%	1.11
silo prices down 10%	21'523'509	20.57%	1.04
production costs of silos increasing 10% *	36'762'832	26.17%	1.06
** +10% on inputs for silos*			

The agrodealers activity is highly capital intensive, therefore agrodealers as very important stakeholders to fuel the entire PHT value chain.

4.4 CBA4 – entire project

As explained in chapter 3.4, the calculation of the CBA requires assumptions on the adoption of the PHT by farmers, i.e. the demand for PH technologies now and in the coming years. We do not yet have very reliable figures on PHT adoption, therefore this is based on 3 scenarios. Later, when the study of Mathilde Hans-Moëvi will be available[6], we will probably have more solid information to compare with the 3 scenarios.

4.4.1 Adopters of PHTs

The number of adopters was estimated from the table of farmers (farm households) trained by the project as well as some farmers from the same wards (but not trained by the project) and some farmers from the same regions. The figures are shown in the table below. The estimate is classified in a base scenario (as realistic as possible), an optimistic scenario (only achievable with subsidised silos), and a pessimistic scenario.

[6] Bachelor thesis at HAFL (Bern University of Applied Sciences, School of agricultural, forest and food sciences), 2017

New adopters (households)	2015	2016	2017	2018	2019	2020	2021
number of new adopters (base)	103	2 286	7 077	13 292	16 671	3 195	166
number of new adopters (subsidy)	103	2 286	13 071	25 481	33 609	25 125	333
number of new adopters (pessimistic)	103	2 286	2 498	5 206	6 406	2 862	0
Cumulated adopters (households)							
number of adopters (cumulated base)	103	2 389	9 466	22 758	39 429	42 624	42 790
number of adopters (cumulated subsidy)	103	2 389	15 460	40 941	74 551	99 675	100 008
number of adopters (cumulated pessimistic)	103	2 389	4 887	10 092	16 498	19 360	19 360

The adoption rates will depend on several factors that the project can only partly control. Climatic conditions (it will for sure make a difference if the maize production is good or bad during these years), market prices, but also the price of the PHT (in particular silos and PICS bags) are likely to influence the farmers' decisions.

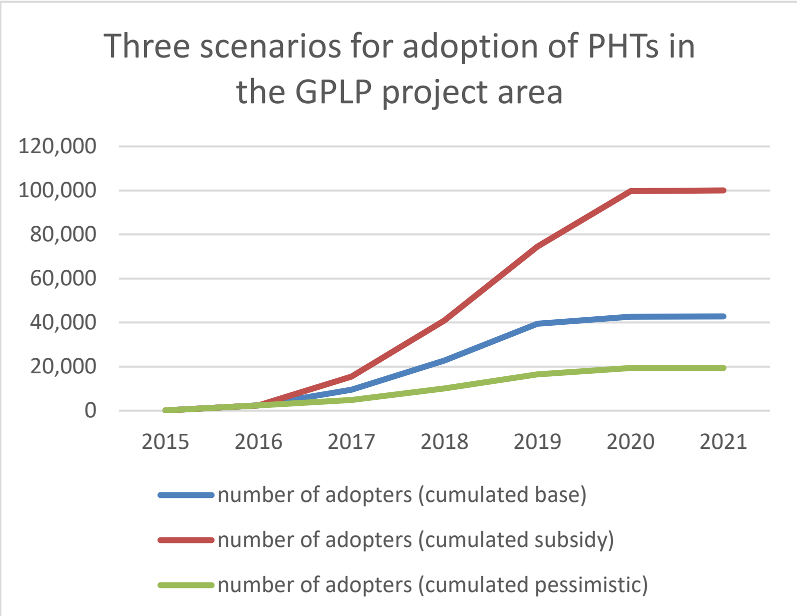


Figure 15 Three scenarios showing different levels of adoption of PHTs in the project area

4.4.2 Artisans for the production of silos

For each scenario, the number of artisans required (calculated with the "standard artisan") will vary. With the optimistic scenario, their number will increase to more than 70, while with the pessimistic scenario, there will be only 14.

number of "standard artisans" needed for	2015	2016	2017	2018	2019	2020	2021
--> base scenario	10	23	27	28	35	7	0
--> scenario with subsidy	10	23	50	54	72	53	1
--> pessimistic scenario	10	23	10	11	14	6	0

4.4.3 Agrodealers

As mentioned earlier, the number of agrodealers is not really relevant here: it does not make a big difference if the silos and PICS bags are sold by a larger or smaller number of agrodealers.

4.4.4 CBA4 – without project management costs

Calculating the result of CBA4 is rather complex, as all the assumptions in the sensitivity analyses above can be combined. Doing this combination may not be very useful, as too many parameters changing at a time are difficult to handle. This is the reason why we have calculated the result for 3 scenarios: base, optimistic and pessimistic as explained above (figure 15).

Note that in this CBA4, the project management costs have been added, only direct project costs are included (training, promotion, capacity building, support, etc.).

		2015	2016	2017	2018	2019	2020	2021
Cost Benefit Analysis of the GPLP project - BASE SCENARIO								
Additional cash flow		-363 139 095	-648 018 762	-1 048 792 960	-968 134 493	1 469 440 110	8 432 275 763	10 058 016 279
farmers		-23 595 700	-507 435 672	-1 193 190 634	-1 216 471 119	1 046 013 368	7 973 451 426	9 377 217 726
artisans		-19 543 395	-12 983 090	40 596 021	108 402 742	141 344 097	176 741 692	134 253 099
agrodealers		-320 000 000	-127 600 000	103 801 653	139 933 884	282 082 645	282 082 645	546 545 455
TOTAL add. cashflow		-1 206 995 295	-1 835 926 362	-2 104 792 960	-1 936 134 493	919 440 110	8 432 273 743	10 058 014 258
Net present value (NPV), discount rate	12%	**4 562 476 817**						
Internal Rate of Return (IRR)		**29.52%**						
Cost Benefit Analysis of the GPLP project - SUBSIDISED SCENARIO								
Additional cash flow		-843 139 095	-839 418 762	-2 315 677 896	-2 465 988 298	1 678 292 653	12 887 493 531	28 764 636 780
farmers		-23 595 700	-507 435 672	-2 571 858 934	-2 943 522 825	768 470 094	11 844 704 602	27 071 658 814
artisans		-19 543 395	-12 983 090	-3 323 094	127 699 816	204 615 947	337 582 318	326 614 329
agrodealers		-800 000 000	-319 000 000	259 504 132	349 834 711	705 206 612	705 206 612	1 366 363 636
TOTAL add. cashflow		-1 686 995 295	-2 027 326 362	-3 371 677 896	-3 433 988 298	1 128 292 653	12 887 491 511	28 764 634 759
Net present value (NPV), discount rate	12%	**13 973 584 187**						
Internal Rate of Return (IRR)		**42.18%**						
Cost Benefit Analysis of the GPLP project - PESSIMISTIC SCENARIO								
Additional cash flow		-203 139 095	-584 218 762	-39 260 867	-5 969 745	1 201 466 002	3 656 541 413	5 998 581 044
farmers		-23 595 700	-507 435 672	-140 053 754	-178 885 278	924 814 438	3 445 373 470	5 631 020 105
artisans		-19 543 395	-12 983 090	48 892 060	102 948 591	135 610 242	70 126 620	94 288 211
agrodealers		-160 000 000	-63 800 000	51 900 826	69 966 942	141 041 322	141 041 322	273 272 727
TOTAL add. cashflow		-1 046 995 295	-1 772 126 362	-1 095 260 867	-973 969 745	651 466 002	3 656 539 393	5 998 579 023
Net present value (NPV), discount rate	12%	**1 332 265 228**						
Internal Rate of Return (IRR)		**19.59%**						

The **base scenario** generated an NPV (12%) of 4’562’476’817 TZS, for an IRR of 29.52%. The good news is that with all the direct project costs included, the CBA is on the positive side. This means that the prospects for a continuation of the activities beyond the project lifespan are good.

The **subsidised scenario** generated an NPV (12%) that is substantially larger with 13’973’584’187 TZS. In fact, this is about three times more! And the IRR reaches 42.18%. This is an excellent result that speaks in favour of subsidy strategy!

The **pessimistic scenario** is poor. The NPV (12%) is still positive with 1’332’265’228 TZS and the IRR is 19.59%. This is too low considering that not all the project costs are included in this calculation.

4.4.5 CBA4 – with project management costs

After testing the model without the management costs, as we did in the previous section, the next step is to include all the costs, i.e. the project fiduciary funds as well as the project management costs.

As this analysis add costs without changing anything to the benefits, the results of this ultimate analysis is necessarily lower than the previous one (under 4.4.4).

The results (see next page) show that only the optimistic scenario can absorb the management costs with a positive NPV (7 551 268 658 TZS) and an IRR of 24.06%. The other scenarios (base and pessimistic) show a negative NPV and a very low IRR.

		2015	2016	2017	2018	2019	2020	2021
Cost Benefit Analysis of the GPLP project - BASE SCENARIO								
Additional cash flow		-363 139 095	-651 582 762	-1 087 083 869	-981 622 096	1 453 506 225	8 416 341 879	10 042 082 395
farmers		-23 595 700	-507 435 672	-1 193 190 634	-1 216 471 119	1 046 013 368	7 973 451 426	9 377 217 726
artisans		-19 543 395	-12 983 090	40 596 021	108 402 742	141 344 097	176 741 692	134 253 099
agrodealers		-320 000 000	-131 164 000	65 510 744	126 446 281	266 148 760	266 148 760	530 611 570
TOTAL add. cashflow		-2 886 017 695	-3 412 217 562	-3 683 083 869	-3 489 622 096	-416 493 775	8 416 341 879	10 042 080 374
Net present value (NPV), discount rate	12%	**-1 754 016 986**						
Internal Rate of Return (IRR)		**7.50%**						
Cost Benefit Analysis of the GPLP project - SUBSIDISED SCENARIO								
Additional cash flow		-843 139 095	-848 328 762	-2 411 405 169	-2 499 707 306	1 638 457 942	12 847 658 821	28 724 802 069
farmers		-23 595 700	-507 435 672	-2 571 858 934	-2 943 522 825	768 470 094	11 844 704 602	27 071 658 814
artisans		-19 543 395	-12 983 090	-3 323 094	127 699 816	204 615 947	337 582 318	326 614 329
agrodealers		-800 000 000	-327 910 000	163 776 860	316 115 702	665 371 901	665 371 901	1 326 528 926
TOTAL add. cashflow		-3 366 017 695	-3 608 963 562	-5 007 405 169	-5 007 707 306	-231 542 058	12 847 658 821	28 724 800 048
Net present value (NPV), discount rate	12%	**7 551 268 658**						
Internal Rate of Return (IRR)		**24.06%**						
Cost Benefit Analysis of the GPLP project - PESSIMISTIC SCENARIO								
Additional cash flow		-203 139 095	-586 000 762	-58 406 322	-12 713 547	1 193 499 060	3 648 574 470	5 990 614 102
farmers		-23 595 700	-507 435 672	-140 053 754	-178 885 278	924 814 438	3 445 373 470	5 631 020 105
artisans		-19 543 395	-12 983 090	48 892 060	102 948 591	135 610 242	70 126 620	94 288 211
agrodealers		-160 000 000	-65 582 000	32 755 372	63 223 140	133 074 380	133 074 380	265 305 785
TOTAL add. cashflow		-2 726 017 695	-3 346 635 562	-2 654 406 322	-2 520 713 547	-676 500 940	3 648 574 470	5 990 612 081
Net present value (NPV), discount rate	12%	**-4 948 954 666**						
Internal Rate of Return (IRR)		**-5.18%**						

5 Discussion

5.1 CBA4 – project money vs farmers' money

The evolution of the costs paid by the project and the investments made by farmers over time is shown in figure 16. This is a logical evolution considering that the project has to make initial investments (developing skills and capacities, raising awareness, promoting technologies) before farmers start investing in PHTs.

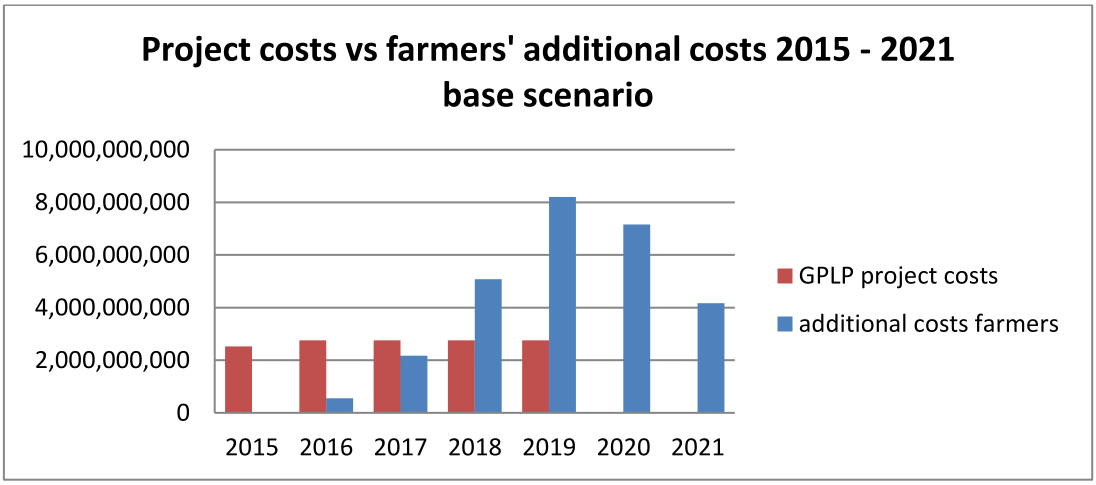


Figure 16 Evolution of costs over time: GPLP costs and farmers' additional costs for PHTs in the base scenario

The base scenario corresponds to approximately 40'000 farm households buying metal silos, PICS bags and PP bags with chemicals (as depicted in the "average farmer", see chapter 3.1) in the project area by 2021. After project termination (in 2019), the number of adopters continues to grow slowly, but much less than during project support (see also figure 15). In this scenario, the money invested by the project (total project costs) induces an investment of farmers that is double this amount within the timeframe 2015 to 2021.

The optimistic scenario foresees that the total number of farm households buying the PHT package in the project area will reach 100'000 by 2021. To achieve this, specific measures are required, such as a massive facilitation of the farmers' access to the technologies, e.g. with subsidies and other supportive measures (including reduced taxes on imports of metal sheets). In this case, the farmers would invest more than 4 times the amount invested by the project over the same period of time.

In the pessimistic scenario, there would be only about 20'000 farm households engaging in PHTs by 2021. In this case, the farmers' investment would only be below the amount invested by the project, and as shown above, the CBA result would be poor. This may happen if many negative influences happen simultaneously: low rainfall resulting in poor yield of maize, high prices of silos and other PHTs, low market price for maize, etc.

5.2 Financial vs economic CBA

The results shown so far reflect the project situation now and in the future, at market prices. To make a true economic analysis with CBA4 we still have to make some adjustments of prices (from financial to economic):

There is one major point where this is relevant: the metal silos are built with imported components (metal sheets, soldering sticks, etc. on which an import tax of 18% is due. In the economic calculation, this is excluded, making the production of silos cheaper and therefore the project more profitable for the country's economy.

5.3 Subsidies to boost adoption of PHTs

Overall, the study has shown that the adoption of improved post-harvest practices and technologies is profitable at farmers' level, but that the silos are still too expensive for a broad dissemination / adoption. We have good reasons to believe that a subsidy on metal silos would strongly foster the demand, along with a choice of payment modalities (including delayed final payment, payment in kind (grains), etc.).

Subsidies are usually not considered a sustainable way of promoting development activities. However, in the case of the metal silos in Tanzania, the situation is slightly different: firstly, the metal silos are long lasting equipment that will benefit their owners during at least 20 years (probably much more). Secondly, subsidizing does not mean distributing free of cost! The farmers must contribute their share. Thirdly, the overall profitability of the project is greatly improved if the number of silos increases dramatically during the second project phase (CBA4 shows that the NPV is 4-5 times higher with the optimistic scenario compared to the base scenario). This issue is further discussed in Box 1 and in the recommendations.

5.4 The negative influences

Besides the sales' price of the PHTs, the main factors that reduce the profitability and potentially the demand from farmers for the PHTs are low yields (of maize and other staple crops), and small price differential between the price at harvest time and peak price during the lean season.

Improving crop production is not within the scope of the project. We do not think that the project should get involved in the supply of inputs, improved varieties, and technical advice, nor in the provision of irrigation facilities, which are the main factors that can ensure good yields.

The silo is mostly not used for speculation on the crops. The main purpose of the silo is to secure the food for the household's own consumption. This is highly appreciated by the few owners of metal silos, especially because their grains will keep well without chemical treatment. In rural households, the metal silo can be compared to the fridge of an urban household.

5.5 PHTs contribute to Tanzania's food security

Tanzania is storing an emergency stock of grains. This central storage has a cost that includes the buying price of the grains, the management, the losses during storage, the transport and logistics, etc. The metal silos and PICS bags are a decentralized storage of grains that also contributes to the country's food security. If the number of silos can be increased to reach 100'000 (as in the optimistic scenario), this corresponds to a storage volume of at least 50'000 t (this corresponds to 20% of Tanzania's reserve[7]).

5.6 The beneficiaries of GPLP

The **farmers** are likely to adopt a post-harvest strategy that combines the different technologies. The project has a role to play to promote these strategies and to adapt them to the various household clusters (referring to the CGAP study[8]). With improved PHM, the farmers will improve their food security and their income, two essential pillars of their livelihood.

With increasing demand for metal silos, the **artisans** will clearly benefit from the activity, and many of them will become professional producers of silos. If the demand increases very fast, it could even become a problem to satisfy the demand.

The **agrodealers** are important stakeholders, on the one hand through their network of clients (farmers) and also because of their role in pre-financing the production of silos. With increasing adoption of PHTs, agrodealers will increase their benefit from the dissemination of PHTs and they may also sell more inputs for the crops. It is likely that their core

> ***Box 1***
> ***Discussion of the findings of the MIT study in Uganda***
>
> *In its findings, the study conducted in Uganda by the MIT (2017)[1] states (among other results) that "Supply chain strengthening offered a better foundation for storage technology adoption than longer-term subsidies". This result needs to be discussed with regard to the situation of the GPLP in the Central Corridor of Tanzania.*
>
> - *Subsidy rate in Uganda was very high (70%) and it was introduced independently from the willingness to pay of farmers*
> - *In Uganda, subsidies were planned over a ten-year period whereas in Tanzania, what we propose is a much more focused and targeted strategy (see recommendations)*
> - *The supply chain of PHTs in Tanzania can be further supported and strengthened in the second phase, but there will not be enough time to earn the benefits from that (second phase ending in 2021).*
> - *With a targeted subsidy strategy in Tanzania, the project will have to strengthen the supply chain anyway, as the demand for PHTs may exceed the existing capacity to meet the demand.*
> - *Boosting the demand should not be based on subsidies only, reducing the production costs of the PHTs is another serious opportunity (e.g. reducing import tax on metal sheets and supplies)*
> - *We may argue differently for the GPLP if the project had a perspective of two more phases. With only one phase left, the project should put all its efforts in boosting the demand for PHTs.*
> - *The risk exists that the adoption of PHTs will decline after project end, and this could be even more the case with a subsidy strategy. On the other hand, the silos that will be in the households will remain there and they will be used, contributing to sustainably improve the farmers' food security. In terms of impact, having 100'000 silos compared to 40'000 or even 20'000 makes a big difference!*

[7] http://www.nfra.go.tz/pages/storage; in total the National Food Reserve Agency (NFRA) owns 30 storage facilities with a total storage capacity of 246,000 Metric Tons (MT).

[8] National survey and segmentation of smallholder households in Tanzania, CGAP, May 2016

business will remain seeds, fertilisers, while PH technologies will gradually become more important in their business.

5.7 Attribution of benefits

One question remains: how to assess the attribution of benefits of the GPLP? The GPLP is not the only project that promotes PHM in Tanzania. The present analysis has a strong focus on the farmers trained by the project. The costs that we considered in the analysis include the project funds, the farmers' costs (to buy the PHTs), etc. The costs that are not included are the Government costs (extension, agriculture staff) who also shared the work, especially in the training campaigns. This may require a small reduction of the attribution of benefits.

6 Recommendations

The following recommendations are addressed to the project and other project stakeholders:

1. The "average farmer" that we used in the present study should be further refined, e.g. considering the clusters of the CGAP study[9]. Taking this into account, the project should promote post-harvest strategies that match the specific needs of the farmers, combining different PH practices and technologies.

The number of metal silos required per household depends on the household size and on the production capacity. Silos were mentioned to be useful even in case of low maize yields: filling the silos (even buying maize from the market or from neighbours if not enough own production) allows a secure food supply for the household. Combined with PICS bags (for medium term storage) and PP bags (with chemicals) for shorter duration storage, will be a meaningful strategy for farmers. Some farmers who are growing different types of grains as staple food (sorghum, finger millet, etc.) may also adapt the strategy to their specific needs.

2. We strongly recommend putting a high priority on boosting the demand for PHTs and especially metal silos during phase 2. The demand can be boosted by several measures including:
→ demonstrating the usefulness of the technology for the farmers (this was done in the awareness raising and promotion campaigns in phase 1)
→ improving the access to the technology: microfinance, payment modalities, etc.
→ reducing the price of the technology: subsidies and / or reduction of production costs

To maximize the impact of GPLP within the given timeframe (there is most likely only one project phase left), boosting the demand for PHTs should be the top priority of the project for the second phase. Boosting the demand can be achieved by convincing the farmers of the usefulness of the technology (this was largely done during the first phase, and the farmers we met seem entirely convinced already), by facilitating access to the technology and by reducing the price of the technologies. The willingness to pay for metal silos shown in figure 3 is a clear signal: at lower prices, the demand can be at least doubled or even tripled (high price elasticity of the demand). How much would this cost to the project?
If the strategy consists of subsidizing one silo of 500kg per household (= targeted subsidy) during 2 years (subsidy limited in time), the project may subsidize at the maximum 40'000 silos. If the market price is 230'000 TZS and the subsidized price is 150'000 TZS, this corresponds to a subsidy of

[9] National survey and segmentation of smallholder households in Tanzania, CGAP, May 2016

80’000 TZS per silo (or approx. 36$). Total amount of the subsidy = 1’440’000$. To buy the silos, the farmers would pay the remaining 150’000 TZS per silo (approx. 68$) corresponding to an investment of 2’720’000$. In addition, the farmers are likely to buy more silos (at full costs) if they want to have more than one silo or a larger silo, which means even more investment from their side. Reducing production costs of silos is another way worthwhile exploring: if the import tax of 18% on the main supplies (metal sheets and soldering sticks) can be reduced or cut, this would also support the demand for silos (i.e. continue policy dialogue with Government).
Even if the demand is not sustained after the project end, the silos that will be in the farm households by then will remain there and be used for at least 20 years, which will be valued as a substantial impact of the GPLP. However, we do not believe that the demand will drop after the time of subsidies, because i) the subsidy level we propose is modest, ii) the technology will remain affordable even without the subsidy assuming payment facilities in the future.

3. Continue supporting the PHT value chain to ensure the timely supply of metal silos and other technologies (while maintaining quality standards).

The artisans are important partners supplying the metal silos. They should be able to cope with an increasing demand (this may require specific support from the project in terms of organisation, management and technical skills). For the artisans, increasing demand for silos should encourage them to become more professional and to increase their profit from this activity.
The agrodealers are key players, especially as they can contribute with capital, along with the micro-finance institutions. The agrodealers are also important to improve the crop production (as they are the main suppliers of seeds and fertilisers). Agrodealers may also require some support from the project during the second phase, especially in terms of promotion

4. The project should not get involved directly in supporting the crop production (this is not the scope of the project) but we encourage the project to develop synergies with other stakeholders (e.g. government agricultural services, extension, other projects) to improve the maize crop (yield level and yield stability).

We assume that high maize yields are a strong incentive for farmers to invest in PHTs. Firstly because more maize production means more cash (assuming maize prices are not falling), secondly because more maize increases the relevance of on-farm storage.
Developing synergies with important players of the maize value chain will contribute to improve the productivity of maize.

5. The project is encouraged to bank on the argument of food security at household level to show the value of the grain storage strategies promoted by the project. This is important in the policy dialogue with the Ministry of Agriculture.

In the dialogue with the Government, the project should emphasize the relevance of the promoted PHTs (and in particular the metal silos) to gain public support to this strategy. In the medium to long term, the Government may even contribute to the promotion with some additional subsidies, e.g. after the end of project subsidies.

6. The GPLP approach is well adapted to the farm sizes that we have met during the field visit (smallholders, with up to 2 ha of maize). In areas where maize production is more important, different strategies may need to be developed.

This goes back to recommendation 1. Small metal silos for individual storage may be a more expensive storage system (costs per tonne stored) but it has a higher cultural acceptance as compared to collective storage. The farmers in the project area also emphasized the value of the promoted PHTs for the quality of the grain: airtight storage does not require chemicals; therefore the grains can be used for human consumption without any fear for the people's health. This could even be supported by the project, with the elaboration of a label certifying that the grain was stored without any chemicals.
For larger farmers, e.g. farmers producing more than 5 tonnes of grains, the metal silos of 500kg may not be so relevant. Therefore the farm size is an important parameter for the choice PHM strategy.

Annex 1 Specific tasks and deliverables of the CBA mandate

Tasks / Activities:

- Analyse GPLP project log frame, quantified indicators, measurement system (M&E) and achievements
- Analyse and select together with project team the most relevant postharvest storage technologies to be included in the CBA.
- Develop a workable CBA model in discussion with the project team quantifying the most relevant cost and benefits for the selected storage technologies
- Establishment of a result chain to illustrate the attribution
- Calculate the CB ratios; including a sensitivity analysis for the financial analysis considering different grain loss and price scenarios (see also CBA conducted by DAI for the former EGSP project funded by SDC).
- Provide a 3 hour “crash course for project staff how to interpret major results and future use of the CBA model established.
- Provide recommendations regarding improvement of the MRM system to provide reliable data for future CBA (financial and economic analysis).
- Present preliminary findings of the study in Tanzania to the project and SDC-COOF at the end of the mission
- Report writing including analysis, explanations and recommendations

Deliverables

- A comprehensive CBA (financial and economic analysis) in line with How-to-Note SDC10 containing
    - An EXCEL spreadsheet, allowing later application/modification of assumptions and further sensitivity analysis
    - An explicit description on how cost and benefits were derived, the underlying assumption, and how the attribution of the project has been modelled
    - A presentation of the preliminary key results to staff of SDC and project
    - A draft report of max. 15 pages (plus Annexes) to be submitted by 5th July 2017.

[10] *SDC How to Note: Financial and Economic Analysis of Projects with a focus on Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA), SDC 2015*

Annex 2 Mission programme

Field Mission Program - Dr. Dominique, HAFL

Dates	Days	Activities	Location	Respon-sible	GPLP / HELVETAS
May-early June		Document study and preparations in Switzerland	Switzerland	DGU	
11.6	**Sun-day**	Travel to Tanzania	Dar, stay in hotel near airport	Consult-ant	Hotel booking for Dominique at FQ Hotel in DAR – Graciana
12.6	**Mon-day**	Travel to Dodoma (by air),	Dar-Dodoma	GPLP / CO	Hotel booking at St. Gasper – Graciana
		Briefing with GPLP team	GPLP Office		Pick up from Airport – Gra-ciana
		Input CBA with project staff and initial discussion on CBA methodology	GPLP Office		Briefing meeting – GPLP team
13.6	**Tues-day**	Exchange with Mathilde, discussion with project about her research Preparation of checklist and field visit	GPLP Office	GPLP	GPLP Office
14.6	**Wednesday**	CBA modelling and discussion with GPLP	GPLP Office	DGU	GPLP Office
		Meeting with GPLP team - checklist for data collection and preparation for field visit	GPLP Office		
15-18.6	**Thurs day - Sun-day**	Field visit for data collection CBA Test questionnaire for adoption rate study / Mathilde	Hanang and Kondao	DGU / Mathilde / Shamim	Field visit to Kondoa and Hanang (4 days) Mathilde also joins - test questionnaire with one group Meetings with farmers group, artisan, agrodealers
19-21.6	**Mon-day - Thurs day**	Data collection / analysis for CBA Support / inputs to adoption rate Mathilda thesis	GPLP Office	DGU / GPLP	
22.6	**Thurs day**	Debriefing meeting with GPLP	GPLP Office	DGU / GPLP	Thursday debriefing with GPLP project team
23.6	**Friday**	Fly back to DAR	Dodoma-Dar	DGU. SAR,	Hotel booking at DAR – Graciana
		Briefing with HELVETAS and SDC (2.00 PM)	HELVETAS Office		Pick up at airport and travel to SDC – Graciana coordi-nate with Nasra
			SDC Office		Debrief with SDC – Shiva
24.6	**Satur-day**	Report writing Travel back to CH	Dar	DGU	Taxi to airport
June-early July		Report finalization,	Switzerland	MFI	
		Debriefing with PC HO.			

Annex 3 Glossary of terms used in CBA

The CBA methodology and its application in the context of development projects is explained in details in the e-learning tool of SDC that can be found under http://deza-pcmi-lernbuch-3.prod2.lernetz.ch/module-6-en/5-glossary#Ti365

The most important terms are explained here:

NPV = Net Present Value

The sum of all discounted costs and benefits is called the net present value (NPV). This sum reflects how much the project will earn. NPV is usually calculated by adding the present value of future cash flows, residual values, and interest less investment costs, operational costs and future expenses. NPV is dependent on the value of the discount rate used to calculate these costs since the discount rate is used to calculate values over time (see also discounted costs, discounted benefits). The NPV method is used for evaluating the desirability of investments or projects.

The minimum condition for accepting a project is a positive NPV.

IRR = Internal Rate of Return

IRR is the rate (similar to an internal interest rate) that is generated by a project or an enterprise. It is an indicator of the profitability of the project / enterprise. If the IRR is equal to the discount rate then the discounted costs equal the discounted benefits, that is it would just break-even at that particular rate (see also discounting). The IRR is the discount rate at which the NPV (see NPV) for a project equals zero. This rate means that the present value of the cash inflows for the project would equal the present value of its outflows.

The condition for a project to be acceptable is that the IRR exceeds the discount rate.

Discount rate

The discount rate refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows. The discount rate in DCF analysis takes into account not just the time value of money but also the risk or uncertainty of future cash flows; the greater the uncertainty of future cash flows the higher the discount rate. High discount rates tend to penalise long-term projects, such as environmental protection, and to favour short-term projects and projects with quick-benefits.

In the case of Tanzania, the discount rate considered is 12% based on information from the Central Bank

BCR Benefit Cost Ratio

Ratio of (discounted) costs to benefits: total discounted benefits divided by total discounted costs.

The condition for a project to be acceptable is a ratio >1