Technical report:
Economic Viability of Ware Potato Storage in Ambient Stores in Eastern Uganda

Expanding Utilization of Roots, Tubers and Bananas and Reducing Their Postharvest Losses

July 2017

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EXECUTIVE SUMMARY

Pilot potato ambient storage facilities with a capacity of 45 tons have been introduced and piloted in eastern Uganda by the RTB-ENDURE project. As part of the project, storage trials have been conducted to evaluate the storability of selected varieties. This report presents the key results of the analyses conducted to assess the economic viability of storing potatoes at farm level.

Potato on-farm storage in ambient store is a viable and potentially highly profitable business in eastern Uganda. We found that the longer the storage period, the higher the profitability of the venture. Varieties with long dormancies should be selected for storage. However, due to the short dormancy period of currently available varieties, at the moment it is not possible to recommend storing potatoes for more than 9 weeks. In most scenarios storing potatoes for 6 weeks would still represent a viable business. At current market prices, potatoes are sold at about 350 UGX/kg during the peak harvesting season. Even when taking into account the highest store construction cost ($14,500) farmers will realize an impressive UGX 6.5 to 9 million marginal profit per season by storing tubers for 6 and 9 weeks, respectively. This corresponds to a marginal profit per kg of UGX 145 to 200.

Based on the results of this study, some key recommendations can be provided for ensuring the viability of the business. First, the construction cost of the storage facilities should be kept low and, at this regard, promising innovations have been developed by the RTB-ENDURE project with last generation store (45 tons capacity) built at a cost of about $6,000. Unsurprisingly the highest profitability is achieved with lower construction costs ($6,000) and longer storage period, i.e. 9 weeks (BCR: 7.7; NPV: UGX 134 million; IRR: 109%; ROI: 668% and payback period of less than a year). The profitability is considerably reduced when the highest construction cost ($14,500) is assumed but storage remains a viable business even in the least favorable scenario characterized by extremely high (and unlikely) construction cost and a short storage period of just 3 weeks (BCR: 1.6; NPV: UGX 31 million; IRR: 14%; ROI: 64% and payback period of less than four years).

Second, the sensitivity analysis showed that farmers should have the capacity to fill the store close to its full capacity. The analyses showed that the profitability is reduced or, in some scenarios, even compromised when the farmers are able to fill only half of the store. While storing potatoes is a profitable to highly profitable business in almost all scenario, it becomes not viable when these two factors are combined (high construction cost at $14,500 and only half-filled store).

Third, the cost of storage losses, and in particular economic losses due to quality degradation, may be high but this is outweighed but the high market price that stored potatoes would fetch. Storage remains viable even when losses are assumed double than the ones actually recorded during the storage trials.

Therefore, while the identification of good quality varieties with longer dormancy period would been important for promoting the storage all tubers, the key enabling factors for on-farm storage are mostly related to engineering aspects to keep the storage construction cost low and an enhanced capacity of small-scale farmers to work together to ensure that the stored utilization is optimized through appropriate collective action mechanism or specific institutional arrangements with other stakeholders in the value chain.

Despite the promising results of the economic analyses, it is worth making a note a caution: the economic viability of storage is primarily dependent on the differential between market price at harvest and price that the market is willing to pay for tubers stored for a certain period of time. While we have attempted to identify typical price trends over the last few years, storage may not be recommended during some specific seasons characterized by unusual high prices during the harvesting season (e.g. due to drought in other important potato production areas in the region). It is therefore recommended to keep on monitoring seasonal market prices for a few more years before promoting large scale adoption of improved storage technologies.

1. INTRODUCTION AND PROBLEM STATEMENT

Potato is a semi perishable crop that can be stored properly with limited postharvest losses (PHL) compared to most of other fruits and vegetables. Potatoes can be stored for up to nine months if a variety with long dormancy is stored in a suitable storage facility (Mbugua et al., 2016). According to Tesfaye et al. (2010), in Uganda about 95% of potatoes harvested are sold fresh with limited value addition and most farmers sell potatoes immediately after harvest. Potatoes in Uganda are mainly grown in the high-altitude regions (south-western Uganda and eastern Uganda). The demand for potatoes in Uganda is increasing as a result of rapid urbanization and population growth. However, seasonality in production is a major constraint that coupled with poor storage facilities result into price fluctuations and high PHL (up to 40%), especially during bumper harvest. During the bumper harvest, surplus of supplies causes market prices to reduce. In other periods of the year, when potatoes are immature, there is scarcity on the market forcing market prices to drastically increase (Bonabana-Wabbi et al., 2013).

According to Walker and Fugulie (2006) the demand for ware potato storage is reflected by price seasonality especially in the tropics. Improved storage is among the best options to reduce price fluctuation and PHLs for ware potatoes that affect producers, traders, processors and consumers, particularly when the surplus exceeds the demand. Enhanced storage facilities and postharvest practices have the potential to ensure that potatoes are on the market throughout the year at an affordable stable price (Wasukira et al., 2014a). However, crop storage can be risky if it is not well managed. Moisture loss, shrinkage, pest and disease damage and sprouting may occur during the storage period resulting into losses in quantity and quality. But if the benefits for storage outweigh both the costs of storage and the storage losses then storage is economically viable (Bevan et al., 1997; Fuglie, 1999). Technologies such as cold storage can be used to extend the shelf life of potatoes in other countries such as Bangladesh, USA and India but in Uganda this may be too expensive for potato value chain actors, primarily because of limited access to electricity in producing areas. Other technologies have been developed in addition to cold storage such as ambient stores that can keep potato in good condition under ambient conditions for about three months to be later released on the market in periods of scarcity. This innovation is currently being tested and validated in eastern Uganda in districts of Mbale, Kapchorwa and Kween by the International Potato Center (CIP) in collaboration with Self-Help Africa, the National Agricultural Research Organization (NARO), and Makerere University in the framework of the EU/IFAD-funded project "Expanding Utilization of Roots, Tubers and Bananas and Reducing Their Postharvest Losses" (RTB-ENDURE). A similar storage technology has

been adopted in Bangladesh and Kenya and has proved to be economically viable (Walingo et al., 2003).

The project is testing and validating storage facilities, however there is limited knowledge on their economic viability in Uganda. Potato farmers, traders and processors need such information if they are to invest in ware potato storage. Therefore, a study has been conducted to analyze the economic feasibility of potato storage at farm level under ambient conditions.

1.1. Objective of the study

To assess the economic viability of ware potato storage using ambient store technology in eastern Uganda.

1.2. Justification for the study

Poor postharvest handling practices and rudimental storage facilities limit storage of ware potato to a short period and lead to high postharvest losses and reduced income from sale of potatoes. There is need to increase the shelf life of potatoes and improve postharvest management practices in order to reduce PHL and increase incomes of potato value chain actors. Prior to recommend the adoption of the recently introduced ambient storage facilities in eastern Uganda by farmers, traders and processors it is necessary to analyze their economic feasibility by looking into the relevant benefits and costs.

2. LITERATURE ON ECONOMICS OF STORAGE

According to Working (1949) in his article about crop storage, the difference between current prices (at harvest time) and future prices (at time of deferred sales of stored crops) should be above or equal to cost of storage. If the prices between seasons increase then the storers will obtain a price margin which means that they will earn a gross benefit per unit stored at harvest for later sales in period of scarcity. Therefore, for storage to be profitable or to earn net benefits the price margin for stored potatoes should be higher enough to cover all the storage costs incurred by the storers such as labor, maintenance costs, storage depreciation and storage losses. Conversely, if the storage price margin is low and unable to cover the costs incurred for storage then a net loss will be incurred by storers and storage is not economically viable. If the net benefits from storage are large then the storers will be motivated to store. However, if storage is highly profitable, the quantity of stored crop, and hence the aggregate supply during the off-season, are likely to increase in the long term, leading to reduced storage price margin. The point where the storage margin is equal to

storage costs is the equilibrium point where storers have no incentive to either increase or reduce the quantity stored.

The model for crop storage is graphically presented in Figure 1. Total production is marketed in two seasons: at harvest (H) and during postharvest/storage season (S). The intersection of the demand and supply at harvest determines the price at harvest (P_H). As time progresses the supplies still in storage are released to market and the market price raises to P_S to compensate for storage costs.
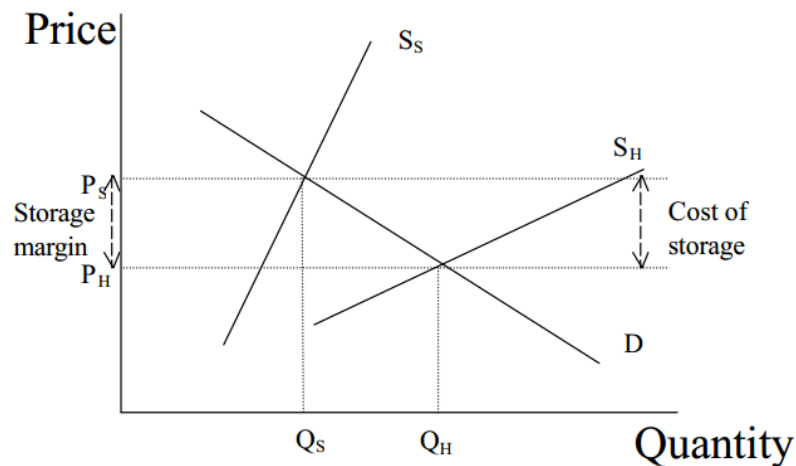
Figure 1: Interaction between demand and supply between peak and scarcity seasons (Fuglie, 1999)

Figure 2 shows the progression of market prices over several seasons. Every year prices fall (P_{HI}) during harvest period (H) and rise (P_{SI}) during scarcity period. This higher price during scarcity should compensate for cost of storage before the new freshly harvested crop arrives to the market and prices fall again.
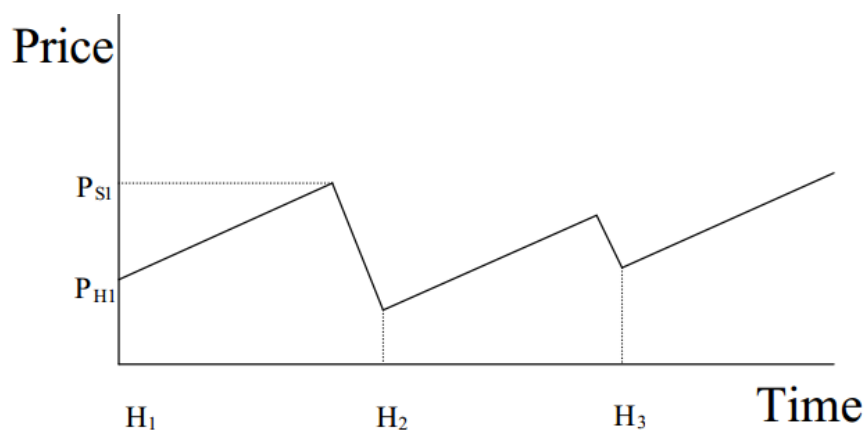
Figure 2: Price fluctuations during peak and scarcity seasons (Fuglie, 1999)

According to Fuglie (1999), in reality prices and conditions of storage are uncertain. Therefore, storers may face risks that may result from poor storage management leading to losses in quality and quantity and price fluctuations that may cause a net loss in income. This implies that if the storers are risk averse they have to include a price premium in their storage costs to enable them compensate for undertaking a risk venture of storage rather than selling their produce immediately after harvest.

3. METHODOLOGY

Primary data were collected from Mbale, Kapchorwa and Kween districts using qualitative and quantitative techniques between 2015 and 2016. These districts were purposively selected because they are among the major producing areas for potatoes and hosting the RTB-ENDURE project sites where pilot ambient stores have been constructed. The fixed and variable costs incurred by farmers operating the ambient store were obtained from key informant interviews. Monthly prices (wholesale) were obtained from Farm Gain Africa and discounted by transport cost to calculate the farm-gate prices. These prices were then validated by project beneficiaries, and outliers managed accordingly, in order to estimate revenues as a result of deferred sales of stored potatoes. Data on the storage physical and economic losses (proportion of diseased, rotten and sprouted tubers either thrown away or sold at discounted price) were collected at 3 week intervals in pilot stores as part of a parallel RTB-ENDURE research aiming at assessing the storability of a number of potato varieties. Data were analyzed using MS Excel.

3.1. Variables to be considered in the analysis

3.1.1. Benefits

Benefits of storage refer to the higher price that stored potatoes can fetch in the market. In fact the tubers are expected to enter the store at the end of the peak harvesting season, when farm gate prices are at the lowest, and to be sold later on in the year when the market is short of supplies and the prices are higher. The results of the storability trials indicated that all varieties currently available in eastern Uganda, as well as new CIP clones and varieties from south-western Uganda that have been tested, would completely sprout if stored for more than 9 weeks. Therefore it has been assumed that tubers are stored for a maximum of 9 weeks. Three intervals have been identified for the analyses: 3, 6 and 9 week storage. Price at bumper harvest have been estimated at about 350 Ugandan Shillings (UGX) per kg and they increase to UGX 500, 600 and 700 after 3, 6, 9 week, respectively (Table 1). Stored potatoes are expected to be sold as a single batch, except for those that are removed from the store because partially damaged and are immediately sold at lower price. It is worth

noticing how deferring the sales of potatoes by just a few weeks would allow to fetch much higher prices. However, a number of costs would be incurred.

3.1.2. Costs

Investment costs. These include the start-up capital for construction of the store and to buy assets such as weighing scales, wooden trays, etc. It can be from either own farmers' saving or a loan from the bank that has to be paid back in a given period of time with a certain interest rate. Different initial construction costs were considered for the ambient store based on the experience gained by the RTB-ENDURE team during the project implementation: $6,000 (equal to the actual cost of constructing a store based on a revised design following some structural problems determined by the original design); $10,000 (the actual initial construction cost following the original design); and $14,500 (the actual costs incurred for constructing a store following the original design and for reinforcing it at a later stage). The first cost ($6,000) is the one that it is expected would be incurred for constructing new stores in the future. However, in order to provide a more robust analysis, we have computed the economic feasibility assuming also higher construction costs. The store has a capacity to store about 45 tons of potatoes (450 bags) and it will be used by associations' members in both harvesting seasons (main harvests in December-January and July-August). The store is expected to have a life span of 8 years and therefore to be used for 16 harvesting seasons.

Variable costs. They refer to costs strictly related to the storage facility and include store maintenance costs such repairs and disinfection costs, store management and security. Based on the decision made by the executive committees of the associations hosting the stores, storage variable costs were assumed equal to what charged by the associations to their members for accessing store space, i.e. a storage fee of 2% of the revenues from sales of stored potatoes.

Storage losses. Losses as a result of shrinkage, sprouting and damage from pests and diseases during storage are considered as costs. Harvested potatoes have to be graded and sorted to ensure that only good quality wares of marketable size (medium to large) are stored. The proportion of tubers affected by physical losses (deterioration of potatoes to the extent that they do not have any residual value) and economic losses (partially damaged potatoes that are sold at discounted price) at 3 week intervals during storage were obtained from the storability trials. The volume of good quality tubers (sold at full price), partially deteriorated potatoes (economic losses) and completely spoilt potatoes (physical losses) was then computed (Table 1). The average price discount of partially degraded potatoes

was estimated at about 10%. While the magnitude of the discount depends on the type and extent of the damage, this can be minimized by regularly and properly inspecting the stored tubers so to detect the problem at early stage and immediately remove the affected tubers from the store for sale. It is worth noticing that proper inspections will contribute to keep the extent of physical losses at minimum while the extent of economic losses is likely to be higher than in case where tubers are not regularly inspected and allowed to completely rot and/or sprout.

3.1.3. Discount rate

For the sake of the economic analysis, future expected cash flows (benefits and costs) have to be converted into their net present value by using an appropriate discount rate. The discount rate reduces present value of future benefits/costs. The nominal discount rate is the current rate recommended by the Bank of Uganda to be charged by commercial banks on loans issued (12%). In order to take into account that future benefits and costs are likely to be higher than the present ones due the high inflation in the country (6.4% in 2016 according to the Bank of Uganda), a real discount rate which accounts for inflation had to be calculated using the formula below.

$$Real\ discount\ rate = (1 + nominal\ discount\ rate) \div (1 + inflation\ rate) - 1 =$$

$$= (1.12 \div 1.064) - 1 = 5.26\%$$

3.2. Selected indicators of economic viability of storage

3.2.1. Marginal profit

The seasonal marginal profit derived from selling stored potatoes over selling immediately after harvest (without storage) was computed for storage periods of 3, 6 and 9 weeks taking into account the expected marketable volumes of tubers of different grades, the prevalent market price, the expected price discount for partially damaged potatoes and the variable storage cost (storage fee). Furthermore, the marginal profit was also computed assuming a linear depreciation of the initial construction cost over 8 years.

3.2.2. Benefit Cost Ratio, Net Present Value, Internal Rate of Return, Return on Investment and Payback Period

A number of selected indicators have been used to analyze the economic viability of storage. In order to compute these indicators, the annual cash inflows were computed by multiplying the seasonal marginal profits, without storage depreciation, by two (there are two harvesting and storage periods each year). The use of the marginal profits instead of actual revenues

has avoided taking into account all other production and marketing costs that are expected to be equal for all potatoes, regardless if stored or not. The cash outflows refer the construction of the store only since the variable storage costs were already taken into account in the calculation of the seasonal marginal profits.

The Benefit Cost Ratio (BCR) was calculated by using the following formula:

$$\frac{B}{C} = \sum_{i=1}^{n} \sum_{i=i}^{T} B_{ti} \, / \, (1+r)^t \div \sum_{i=1}^{n} \sum_{i=i}^{T} C_{ti} \, / \, (1+r)^t + K_{ti}$$

Where:

B_{ti} is benefits for a technology i in time t

C_{ti} is costs for a technology i in time t

t is the life span

n is the number of technology alternatives developed to be compared.

r is the real discount rate

K_{ti} is the initial capital required for the storage technology

The higher the BCR the more profitable the investment and a BCR above one indicates that the investment is viable.

In addition to BCR the following indicators were computed:

$$NPV = Sum\ of\ present\ values\ of\ cash\ inflows - Sum\ of\ present\ cash\ outflows$$

(expressed in UGX)

$$Internal\ Rate\ of\ Return = The\ discount\ rate\ that\ will\ render\ NPV\ equal\ to\ zero$$

(expressed in %)

$$Return\ on\ Investment = (Benefits - Costs)/Costs$$

$$Payback\ Period = \frac{Initial\ cash\ outlay}{Annual\ cash\ inflow}$$

(expressed in years)

Furthermore, sensitivity analyses have been conducted assuming that i) the store is filled to only half of its capacity (vs completely full); ii) storers incur double than actually recorded storage losses; and iii) the store is half-filled and storage losses are doubled. This was done to understand whether storage was feasible even under less favorable conditions.

4. RESULTS AND DISCUSSION

4.1. Baseline scenario

Farmers selling potatoes immediately after harvest would realize a revenue of UGX 15,750,000 per season (Table 1). Despite the increase in storage losses over time, the longer the storage period the higher the revenues. Accordingly, the highest revenue is obtained by selling potatoes that have been stored for 9 weeks (UGX 28,383,158) when farm-gate prices are the highest (700 UGX/kg vs 350 UGX/kg at harvest time). The variable costs are almost negligible and would not significantly affect the seasonal marginal profit. Furthermore, even taking into account the depreciation of store and assuming the highest initial investment for its construction ($14,500) the marginal profit are positive, particularly when potatoes are stored for a longer period of time (UGX 9,029,557 for 9 week storage).

Table 1. Marginal profit from selling stored potatoes

Storage period	0 (Sale at harvest)	3 weeks	6 weeks	9 weeks
Volume stored per season (kg)	0	45,000	45,000	45,000
Selling price of good (UGX/kg)	350	500	600	700
Physical losses in given interval period (%)	-	0.25%	2.39%	0.95%
Economic losses in given interval period (%)	-	0.00%	16.84%	46.32%
Price discount due to economic losses (UGX)	-	10%	10%	10%
Price of partially deteriorated potatoes (UGX)	-	450	540	630
Average price of sold partially deteriorated potatoes (UGX)	-	0	540	611
Volume of potato sold at full price (kg)	45,000	44,889	36,237	14,968
Volume of potato sold at discounted price (kg)	-	-	7,579	28,421
Volume of spoilt potato (kg)	-	111	1,184	1,611
Revenue per season (UGX)	15,750,000	22,444,737	25,834,737	28,383,158
Storage fee, 2% (UGX)	-	448,895	516,695	567,663
Linear storage depreciation - over 8 years/16 storage seasons (UGX)*	-	3,035,938	3,035,938	3,035,938
Marginal profit per season without depreciation (UGX)	-	6,245,842	9,568,042	12,065,495
Marginal profit per season with depreciation (UGX)*	-	3,209,905	6,532,105	9,029,557

* Note that for the construction cost worst case scenario was used ($14,500 converted to UGX at a rate of 1:3,350).

Table 2 presents the results of the economic analyses assuming three different construction costs. All indicators corroborates the results of the marginal profit analyses and suggest that storage is viable under all scenarios. Unsurprisingly the highest profitability is achieved with

lower construction costs and longer storage period (BCR: 7.7; NPV: UGX 134 million; IRR: 109%; ROI: 668% and payback period of less than a year). The profitability is considerably reduced when the highest construction cost is assumed but storage remains a viable business even in the least favorable scenario characterized by extremely high (and unlikely) construction cost a short storage period of just 3 weeks (BCR: 1.6; NPV: UGX 31 million; IRR: 14%; ROI: 64% and payback period of less than four years).

4.2. Sensitivity analysis

Besides considering different storage construction cost, additional sensitivity analyses were conducted to consider some other scenarios that may compromise the viability of the business, namely the capacity of farmers to fill only half of the store, the occurrence of twice the storage losses recorded during the storage trials and a combination of the two.

The factor that would mostly affect the viability of storage is the inability of farmers to fill the store (Table 3, 4 and 5). This would significantly reduce the profitability of the business. Conversely the effect of doubling the losses is marginal. Even when the two scenarios are combined the potato storage remains highly profitable as long as the tubers are stored for at least 6 weeks and the construction cost does not exceed $10,000. Assuming the highest construction costs ($14,500; Table 5) storage becomes a non-viable business if the store is only half-filled and tubers are stored for less than 6 weeks. These are the only scenarios for which the business is clearly non profitable (indicated in italics in Table 5).

Table 2: Indicators of economic viability of storage

Storage period	Store construction cost $6,000			Store construction cost $10,000			Store construction cost $14,500		
	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks
BCR	4.0	6.1	7.7	2.4	3.7	4.6	1.6	2.5	3.2
NPV	59,784,468	102,275,484	134,217,963	46,384,468	88,875,484	120,817,963	31,309,468	73,800,484	105,742,963
IRR	53%	85%	109%	27%	48%	62%	14%	29%	40%
ROI	297%	509%	668%	138%	265%	361%	64%	152%	218%
Payback period	1.5	1.0	0.8	2.5	1.7	1.3	3.7	2.4	1.9

Table 3: Sensitivity analysis for a $6,000 store

Storage period	Store half-filled			Double storage losses			Store half-filled and double losses		
	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks
BCR	2.0	3.0	3.8	3.9	5.4	5.7	2.0	2.7	2.9
NPV	19,842,234	41,087,742	57,058,981	59,091,787	87,669,816	95,150,768	19,495,894	33,784,908	37,525,384
IRR	20%	38%	51%	52%	74%	80%	20%	32%	35%
ROI	99%	204%	284%	294%	436%	473%	97%	168%	187%
Payback period	3.0	2.0	1.6	1.5	1.1	1.1	3.1	2.2	2.1

Table 4: Sensitivity analysis for a $10,000 store

Storage period	Store half-filled			Double storage losses			Store half-filled and double losses		
	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks
BCR	1.2	1.8	2.3	2.4	3.2	3.4	1.2	1.6	1.7
NPV	6,442,234	27,687,742	43,658,981	45,691,787	74,269,816	81,750,768	6,095,894	20,384,908	24,125,384
IRR	4%	17%	26%	26.58%	40.73%	44.30%	4%	13%	15%
ROI	19%	83%	130%	136%	222%	244%	18%	61%	72%
Payback period	5.0	3.3	2.6	2.5	1.9	1.8	5.1	3.7	3.5

Table 5: Sensitivity analysis for a $14,500 store

Storage period	Store half-filled			Double storage losses			Store half-filled and double losses		
	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks	3weeks	6 weeks	9 weeks
BCR	0.8	1.3	1.6	1.6	2.3	2.37	0.8	1.1	1.2
NPV	-8,632,766	12,612,742	28,583,981	30,616,787	59,194,816	66,675,768	-8,979,106	5,309,908	9,050,384
IRR	-4%	6%	13%	13%	24%	27%	-5%	3%	4%
ROI	-18%	26%	59%	63%	122%	137%	-18%	11%	19%
Payback period	7.3	4.8	3.8	3.7	2.7	2.5	7.4	5.4	5.1

5. CONCLUSIONS

The analyses showed that potato on-farm storage in ambient store is a viable and potentially highly profitable business in eastern Uganda. We found that the longer the storage period, the higher the profitability of the venture. Varieties with long dormancies should be selected for storage. However, due to the short dormancy period of currently available varieties, at the moment it is not possible to recommend storing potatoes for more than 9 weeks. In most scenarios storing potatoes for 6 weeks would still represent a viable business. At current market prices, potatoes are sold at about 350 UGX/kg during the peak harvesting season. Even when taking into account the highest construction cost ($14,500) farmers will realize an impressive UGX 6.5 to 9 million marginal profit per season by storing tubers for 6 and 9 weeks, respectively. This corresponds to a marginal profit per kg of UGX 145 to 200.

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appropriate collective action mechanism or specific institutional arrangements with other stakeholders in the value chain.

Despite the promising results of the economic analyses, it is worth making a note a caution: the economic viability of storage is primarily dependent on the differential between market price at harvest and price that the market is willing to pay for tubers stored for a certain period of time. While we have attempted to identify typical price trends over the last few years, storage may not be recommended during some specific seasons characterized by unusual high prices during the harvesting season (e.g. due to drought in other important potato production areas in the region). It is therefore recommended to keep on monitoring seasonal market prices for a few more years before promoting large scale adoption of improved storage technologies.

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