ECONOMIC APPRAISAL OF INERT ATMOSPHERE SILO FOR WHEAT STORAGE

*** Oyebamiji I. T., Olatilewa M. O., Adetayo S. A., and S. N. Oyewole**
Nigerian Stored Products Research Institute (NSPRI), Km 3, Asa-dam road, Ilorin, Kwara State, Nigeria.
*CORESPONDENCE E-MAIL:oyebamijiisaac74@gmail.com Telephone\No.: +2347035925492

ABSTRACT

The study evaluated the economic appraisal of inert atmosphere silo used for wheat storage in Ilorin. NSPRI has developed inert atmosphere silo for storage of grains and this has successfully stored wheat among other grains for four year without quality deterioration, but the targeted stakeholders in grains postharvest value chain have not been able to adopt the technology. Their fear is not far fetch from the uncertainty of how cost effective the technology will be. The study was conducted to appraise the economics of the technology for storage of wheat and other grains. Budgeting and profitability analytical techniques were used to analyze the data generated by the study. The study revealed that storage of wheat using inert atmosphere silo is highly profitable with a *gross margin of ₦5,182,250.00.* Lastly, Return per Naira from wheat grains storage using the silo is 0.44. The return on the investment almost hits 50 % of the financial commitment to the investment made on the Technology (Silo) for grains storage. To reduce postharvest grain losses and increase food security in the country, governments at all levels, Farmers' Association Stakeholders and grains merchants should work with NSPRI on the adoption of the technology.

INTRODUCTION

Wheat, which is one of the most important staple grain food in Nigeria, is mainly produced by small scale farmers in the northern parts of the country and is consumed in one form or the other in virtually every home, restaurants and hotels throughout the country. The crop is the main raw material in the flour mills. Wheat contributes more calories and more protein to the world's diet than any other crop. World trade in wheat also exceeds trade in all other grains put together (Onyibe and Ubi, 2004). Marketing of wheat involves business operations such as buying and selling, transportation, grading, and storage. Storage of wheat and other grains continue to be relevant due to increased food production through agricultural mechanization and food security for the fast increasing population.

Storage of agricultural products is basically the agricultural product safe keeping and quality preservation. The agricultural production seasonality and the dynamics of the consumption process should be considered in order to have efficient storage procedures for preventing or at least minimizing loss during the storage estimated at 20 % which is relatively high (Lorini, 1993). It also contributes to grain safety and hygiene (Rezende, 2002). Storage is an important aspect of food security in developed and developing countries. This is especially important since most cereals, including wheat are produced on a seasonal basis, and in many places there is only one harvest per year, which itself may be subject to failure (Proctor, 1994). Seasonal production leads to fluctuating supply at the international, regional, national or at household levels. The fluctuating supply is in sharp contrast to a stable demand throughout the year and regions. Storage helps to even out fluctuations in market supply, both from one season to the next and from one year to the

next, by taking produce off the market in surplus seasons, and releasing it back onto the market in lean seasons (Proctor, 1994).
Among several factors considered that for a good storage practice are associated with the storage structures, grain processing operations and, fundamentally the stored grains as raw material and not only as a commodity. Therefore, the agricultural product storage should be incorporated in the agricultural value chain which implies adopting control and safety procedures in order to obtain product with quality, mainly to serve the food industries demand and also for consumer's needs (Rezende, 2002). Once a cereal crop is harvested, it may have to be stored for a period of time before it can be marketed or used as feed or seed. The length of time cereal can be safely stored will depend on the condition it was harvested, the needed processing and the type of storage facility to be utilized. Grain stored at lower temperatures and moisture contents can be kept in storage for longer periods of time before its quality will deteriorate. The presence and build-up of insects, mites, molds and fungi, which are all affected by grain temperature and grain moisture content, will affect the grain quality and duration of grain storage. Grain losses contribute to food insecurity and low farm incomes in the Sub-Saharan African countries (Compton, 1992; Azu, 2002).
Ladele and Ayoola (1997) reported that efficient food marketing system would reduce postharvest losses, ensure adequate returns to farmers' investment and stimulate expansion in food production thereby enhancing the level of food security in Nigeria. Food marketing is a very important but rather neglected aspect of agricultural development. Traders therefore had to critically embrace effective storage procedures so as to make their grains acceptable to consumers. In Nigeria, food marketing by farmers and their families mostly in the immediate post-harvest period usually involves a lot of costs. These costs are so high that lowering the costs through efficient marketing system may be as important as increasing agricultural production. Proper storage begins with the condition of the harvested grain, including moisture level and how it leaves the harvester and then is transported and handled. Grain bins should receive a thorough check up and cleaning, including removal of old grains. Ideally it is better to store grains in several small bins rather than a few large ones (Shelton, 2007). Long term grain storage is profitable (Beranek, 2010) and one of the major factors in determination of grain sales is storage structures. Addition of storage facilities is anticipated to increase marketing flexibility thereby strengthening marketing position. Importance of storage structure in grain marketing is highlighted by Oelke *et al.* (2008), who stated that much grain is damaged during storage and can result in reduced profits. Good storage management is essential to prevent spoilage which is caused by mould growth and insect activity.

Statement of Research Problem

The pre- and post-harvest food crop losses among African countries as estimated by AMCOST (2006), was put at about 10 %, which is higher than the global average. This perceived cheating causes discouragement and leads to loss of interest in farming and consequently a reduction in food production. The postharvest policy of the Nigerian Food Security Programme is centered on three tiers of grain storage; Strategic Grain Reserve, Buffer Stock and On-farm storage. The On-farm Storage Programme is supposed to hold 85% of the grains required for food security (Olumeko, 1998). To achieve this, farm level storage is to be complemented with private sector storage stocks which include grain merchants and consumers (Talabi, 1998). Muhammad-Lawal and Omotesho (2008) posited that cereals provide 34 % of the farming households total calorie intake and 47 % of protein supply and therefore recommended increased cereal production. If available the food could be adequately stored and evenly distributed (through efficient national and international markets) each person would be assured of recommended 2700 calories a day (FAO, 1997).

Grain merchants play a prominent role in food storage through their activities as middle-men between producers and consumers hence they store grains throughout the year. Birewar (1990) revealed that the existing on-farm grain storage facilities available in the country are not satisfactory and leads to the maximum storage losses to the extent of about 30 to 40 %. According to Shelton (2007), the grain crop is a major investment that needed to be protected. Especially, storage of wheat is very crucial as Nigeria is not so blessed with favourable environmental conditions required for production of wheat. The little that is been produced locally compared with the country's annual demand calls for appropriate and adequate storage of the available wheat to guide against unnecessary postharvest loss that may result from poor handling. Although NSPRI has developed inert atmosphere silo for storage of grains and this has successfully stored wheat among other grains for four years without quality deterioration, but the targeted stakeholders in grains postharvest value chain have not been able to adopt the technology. Their fear is not far fetch from the uncertainty of how cost effective will it be as an investment that requires high financial commitment. Conducting economic appraisal of this technology for storage of wheat and other grains will allay the fear of the stakeholders and encourage wide adoption of the technology.

Objectives

The main objective of this study was to evaluate the economics of using the inert atmosphere silo as a sustainable grains storage structure for long term storage of grains. The specific objectives are to:

i) Determine the costs and return structure of operations of the technology for storage of wheat for four years.
ii) Evaluate the profitability of the technology for grains storage.

METHODOLOGY

Description of Inert Atmosphere Silo

Inert Atmosphere Silo is a control atmosphere storage structure designed for protecting grains against insect attacks. It is a physical artefact with different components functioning as a unit in controlling insect infestation in stored grains. It is an airtight system with facilities to purge out the air content of the enclosure and replace it with nitrogen gas (N_2), thereby making the system inert and inhabitable for stored products insect pests (Ajayi *et al.,* 2016). It is basically made up of bin, plinth, gallery, gas supply network, monitoring devices and handling equipment (Figure 1). The bin is a cylindrical structure with conical top constructed of food grade coated mild steel plate. It has three outlets for loading, discharging and accessibility. It could be replicated indifferent capacity, but the particular capacity that was used for this study was a battery of two units of 50 tonnes capacity (100 tonnes capacity). The silo is located at the Headquarters of Nigerian Stored Products Research Institute (NSPRI), in Ilorin, Nigeria.

Study Materials

The two varieties of wheat stored inside the inert atmosphere silos are LACRIWHT-2 (Cettia) and LACRIWHT-4 (Atilla-Gan-Atilla) from Lake Chad Research Institute, Maiduguri, Nigeria. LACRIWHT-4 (Atilla-Gan-Atilla) was stored in Silo A while LACRIWHT-2 (Cettia) was stored in Silo B (Ajayi *et al.,* 2016). 100 tonnes of wheat seed was used for the study, with each silo loaded with 50 tonnes.

Study Activities

Series of operations were carried out in the course of the research work in-line with the overall project objective which was beyond the economic appraisal of the technology for grain (wheat) storage. A lot of cost items and activities were involved as detailed in Figure 2.

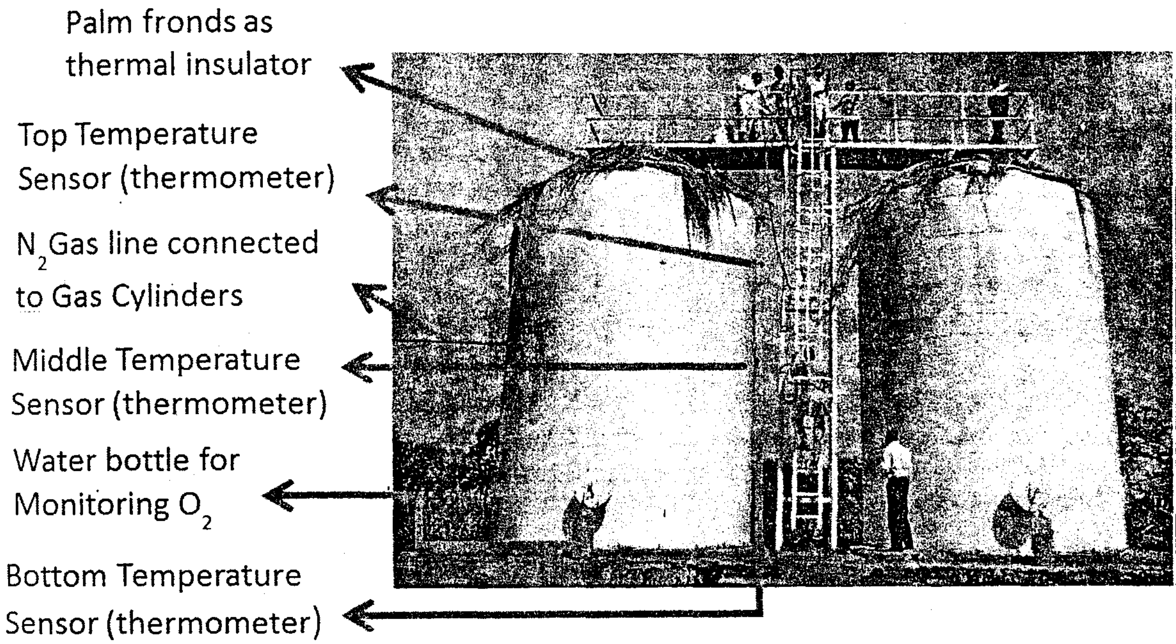
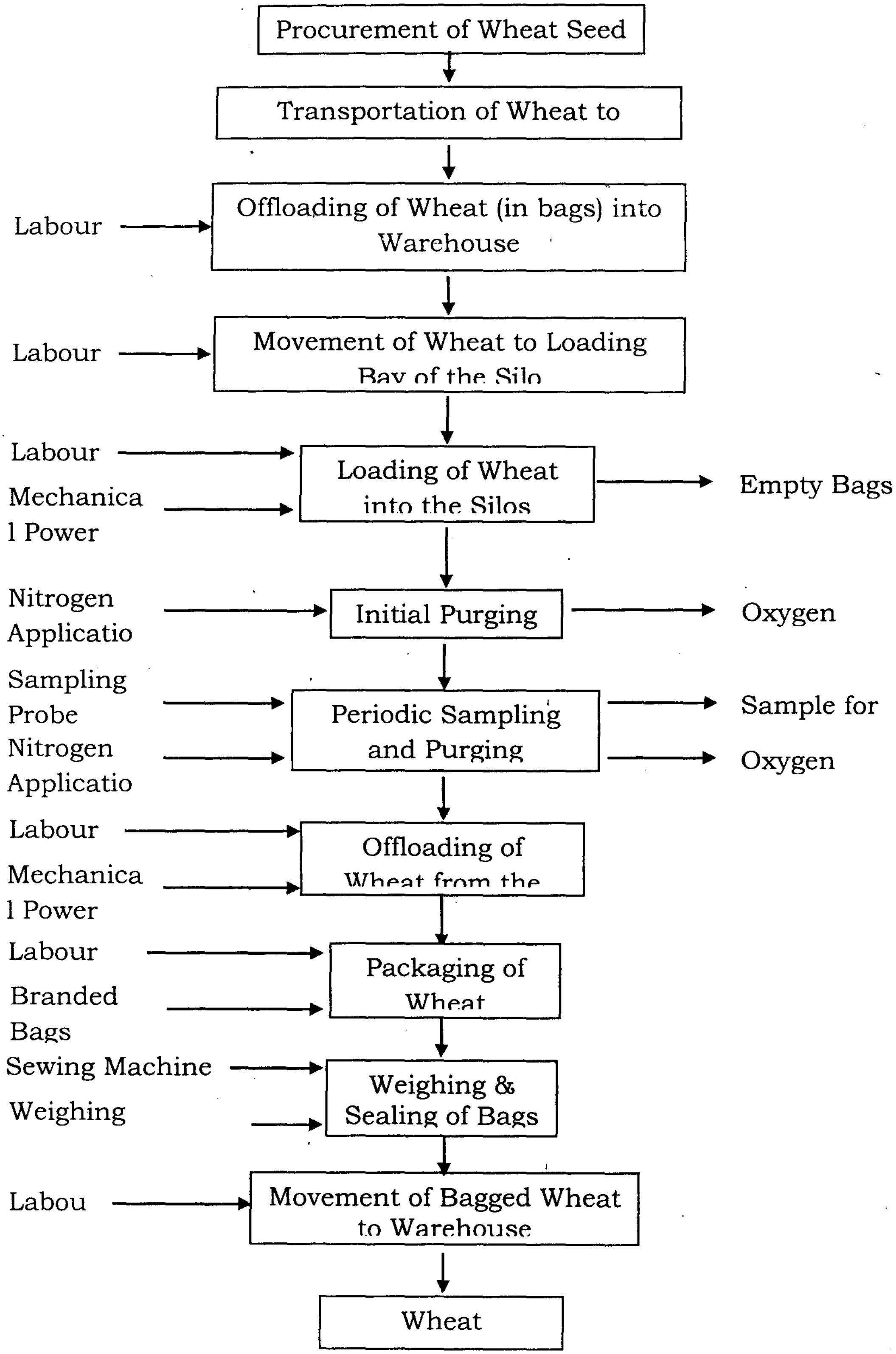


Figure 1: A Battery of Two Units of Inert Atmosphere Silo
Source: Ajayi *et al.* (2016)



Procurement of Wheat Seed
Transportation of Wheat to
Labour
Offloading of Wheat (in bags) into Warehouse
Labour
Movement of Wheat to Loading Bay of the Silo
Labour
Mechanica l Power
Loading of Wheat into the Silos
Empty Bags
Nitrogen Applicatio
Initial Purging
Oxygen
Sampling Probe
Nitrogen Applicatio
Periodic Sampling and Purging
Sample for
Oxygen
Labour
Mechanica l Power
Offloading of Wheat from the
Labour
Branded Bags
Packaging of Wheat
Sewing Machine
Weighing
Weighing & Sealing of Bags
Labou
Movement of Bagged Wheat to Warehouse
Wheat

Figure 2: Operation Flow Chart for Utilization of Inert Atmosphere Silo for Storage of Wheat

Economic Research Tools

1. Budgetary Analysis

Costs and Return structure was adopted for the budgetary analysis as stated by Animashaun and Toye (2012) on feasibility analysis of leaf-based moringa oleifera plantation.

i. **Cost Analysis**

$$TC = TFC + TVC \qquad 1$$

Where, TC is the Total Cost (₦), TFC is the Total Fixed Cost (₦), and TVC is the Total Variable Cost (₦).

ii. **Revenue Analysis**

$$TR = P\ X\ Q \qquad 2$$

Where, TR is the Total Revenue (₦), P is the selling price of wheat per kg (₦), and Q is the Total Quantity of the wheat sold (kg).

iii. **Gross Margin**

$$GM = TR - TVC \qquad 3$$

Where,GM is the Gross Margin (₦)

iv. **Net Profit**

$$NP = GM - TFC \qquad 4$$

Where, NP is the Net Profit

2. Profitability Analysis

Analyses such as Productivity Efficiency / Yield on Investment (PE), Gross Revenue Ratio (GRR), Net Profit Margin (NPM), Rate of Return on Fixed Cost (RRFC), and Rate of Returns on Variable Cost (RRVC) were computed to examine the profitability level of the wheat stored.

i. **Productivity Ratio**

$$\text{Productivity Ratio } (PE) = \frac{TR}{TC} \qquad 5$$

ii. **Gross Revenue Ratio**

$$\text{Gross Revenue Ratio } (GRR) = \frac{TC}{TR} \qquad 6$$

iii. **Net Profit Margin**

$$NPM = \frac{NI}{TR} \qquad 7$$

Where, NI is the Net Income (₦)

iv. **Rate of Return on Fixed Cost**

$$RRFC = TR - \frac{TVC}{TFC} \qquad 8$$

v. **Rate of Return on Variable Cost**

$$RRVC = TR - \frac{TFC}{TVC} \qquad 9$$

RESULTS AND DISCUSSION

The results of the economic analyses of using inert atmosphere silo for storage of wheat for a period of four years are presented in Table 1 below. It revealed that the total revenue from the wheat investment for the period under study is ₦10,800,000.00. A total variable cost of ₦5,617,750.00 was incurred on procurement and storage of wheat. The fixed costs for the technology, prime mover, weighing scale and the bag sewing machine gave the depreciation cost of ₦1,856,400.00. This led to Gross Margin of ₦5,182,250.00; which shows the cost effectiveness of the use of this technology in storage of grains for longer period without quality deterioration. This statement is in conformity with the result of Beranek (2010) on profitability of long term storage of grain.

The net margin of the investment is ₦3,325,850.00. This implies that the technology is highly profitable for the investment when compared with the findings of Kimenju and De Groote (2010). The yield on investment or production efficiency for this investment is 1.4449. This figure showed that the Technology (Inert Atmosphere Silo) is profitable for storage of grains, especially wheat. The Net Profit Margin of 30 % further confirmed the profitability rate of the technology. Moreover, the profitability parameters of Gross Rate of Return, Rate of Return on Fixed Cost and Variable Cost which have a value of 0.6921, 2.79, and 1.59 respectively also confirmed the profitability of the technology as a sustainable grain storage structure. The positive values reflect the gains on the investment which will guide the farmers / investors in making right decision on technology adoption. Lastly, Return per Naira (NI/TC) from wheat grains storage using the silo is 0.44. This is an indication that every N1.00 tied to the use of the silo, 44k will be realized after a period of four years. The return on the investment almost hits 50 % of the financial commitment to the investment made on the Technology (Silo) for grains storage. This is in agreement with the findings of Kimenju and De Groote (2010) which reported high return on investment made on metal silo for grain storage.

CONCLUSION

From the finding, the cost and return on the investment using inert atmosphere Silo shows that the yield on investment or production efficiency of 1.4449 was estimated showing that the Technology will generate about half of the cost as profit. Also with an indication of 30 % of Net Profit Margin confirmed the profitability rate of the technology used. Conclusively, this means that using Inert Atmosphere Silo for storing grains is highly profitable. It is one of the best ways by which postharvest loss in grains could be greatly reduced and food security and safety enhanced as it does not entails use of synthetic chemicals which is responsible for food poisoning and chemical residues in food items. In the light of the findings of this study, the following recommendation is put forward to all stakeholders of food safety and security in Nigeria:

- Governments at all levels, Grain Farmers' Association Stakeholders and grain merchants should work with NSPRI on the adoption of the technology to guarantee present and future food security and safety in the country rather than relying on the National Strategic Grain Reserve that has not been able to solve the postharvest loss challenges of the grain sector of agriculture.

REFERENCES

Ajayi, E. S., M. A. Omodara, S. N. Oyewole, A. R. Ade and F. A Babarinsa (2016). Temperature fluctuation inside inert atmosphere silos. *Nigerian Journal of Technology (NIJOTECH)*. Vol. 35, No. 3, pp. 642 – 646.

AMCOST (2006). Technologies to reduce post-harvest food loss The African Ministerial Council on Science and Technology (AMCOST) of the African Union (AU), Pretoria, South Africa. Retrieved on August 17, 2006 from http://www.nepadst.org/platforms/foodloss.shtml

Animashaun, J. O and Toye, A. A. (2013). Feasibility Analysis of Leaf-Based Moringa oleifera Plantation in the Nigerian Guinea Savannah: Case Study of University of Ilorin Moringa Plantation. ***Agrosearch***; 13(3): 218 – 231.

Azu, J. (2002). Post-harvest loss reduction: OICI Tamale's quick interventions for reducing food insecurity. Ghana, OICI International.

Beranek, M. (2010). Grain Storage as a marketing strategy. Government of Alberta, Agriculture and Rural Development, Alberta, USA.

Compton, J. A. F. (1992). Reducing Losses in Small Farm Grain Storage in the Tropics: Chatham: NRI.

Food and Agricultural Organization. (1997).Technical Background Document for the World Food Summit, Rome Italy.

Kimenju, Simon C. and De Groote, Hugo Economic Analysis of Alternative Maize Storage Technologies in Kenya Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.

Ladele A. A. and Ayoola G. B. (1997). Food Marketing and its Roles in Food Security in Nigeria: In Shaib B, Adedipe N.O, Aliyu, A and Jir, M. M. (eds) Integrated Agricultural Production in Nigeria: Strategies and Mechanisms for Food Security. Proceedings of the National Workshop on Nigeria Position at World Food Summit Abuja Nigeria. Pp 88.

Lorini, I., (1993). Aplicação do Manejo Integrado de Pragas em Grãos Armazenados. In: Anais do Simpósio de Proteção de Grãos Armazenados, 1993. Passo Fundo, RS. EMBRAPA-CNPT, 147 p.

Muhammad, L. A., and Omotesho, O.A. (2008). "Cereals and Farming Household food security in Kwara State, Nigeria". ***Agricultural Journal***: 3(3):235- 240.

Oelke, E. A., Rehm, G. W., Bissonnette, H. L., Durgan, B. R., Simmons, S. R., Noetzel, D. M., Cloud, H. A., Benson, F. J., (2008). Tips for profitable production. College of Food, Agriculture and Natural Sciences, University of Minnesota.

Olumeko, D. O. (1998). The Role of the Crop Storage Unit in the National Food Security Programme. Proceedings of National Workshop on Post-harvest Food Loss Prevention, organized by Crop Storage Unit of Federal Department of Agriculture, June 1998. Pp 29-39.

Proctor, D.L. , ed. (1994). Grain storage techniques: Evolution and trends in developing countries. Vol. 109, FAO agricultural services bulletin no. 109. GASCA - Group for Assistance on Systems Relating to Grain after Harvest. Rome: Food and Agriculture organization of the United Nations.

Rezende, A.C., (2002). Boas práticas de armazenamento: análise de perigo e pontos críticos de controle. In: Armazenagem de Grãos. Campinas, SP: Ed. Bio Genezis, 1000 p

Shelton, D. (2007). Grain Bin Maintenance. Agricultural News leaks, breaks and releases. University of Nebraska – Lincoln, USA.

Talabi, A. E. (1998). Overview of the National Food Security Programme; Strategic Grain Reserve Experience. Paper presented at the National Workshop on Post-harvest Food Loss/Prevention. Organized by Crop Storage Unit of Federal Department of Agriculture, June, 1998. Pp 20-28.

Table 1: Results of Cost Analyses

Variables	Value
Revenue:	
100,000 kg of Wheat	10,800,000.00
TR	**10,800,000.00**
Fixed Cost :	**Depreciation On Fixed Inputs**
Construction of Silo	1,805,400.00
Weighing Scale	30,000.00
Prime mover	13,000.00
Bag Sewing Machine	8,000.00
TFC	**1,856,400.00**
Variable Costs:	
Initial Cost of Wheat	4,850,000.00
Cost of Labour:	160,000.00
Loading of wheat into Silo	225,000.00
Offloading of wheat from Silo	
Packaging Cost:	
Printed poly propylene bags @ 60 per 100 kg	6,000.00
	5,000.00
Sewing thread and needle	12,150.00
Fueling, greasing and lubricating of engine during loading and off loading	
Maintenance Cost:	
Purging of Silo (8 cylinders of Nitrogen gas @ 9200 per cylinder)	105,600.00
Quality control during storage	8,000.00
Servicing of sewing machine	2,000.00
Transportation Cost:	
Conveying of wheat from Maiduguri to Ilorin (NSPRI Headquarters).	250,000.00
TVC	**5,617,750.00**
TC = TFC + TVC	7,474,150.00
GM = TR –TVC	5,182,250.00
NI = TR – TC	3,325,850.00
PE =TR/TC	1.45
GRR = TC/TR	0.69
RRR on FC = GR – TVC/TFC	2.79
RRR on VC = GR – TFC/TVC	1.59
R/₦ = NI/TC	0.4449