Underground Earthbag Structures

Effective Grain Storage for Nigeria

Team 32

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Executive Summary

Grain agriculture has been identified to play a key role as a food staple, and livelihood of individuals living across the sub-Saharan continent of Africa. Although the continent produces more than 112 million tons of grain per year (Fintrac, 2016), farmers are still being detrimentally affected through post-harvest losses. These losses are a result of insect and rodent infestation, inadequate storage and the lack of access to pesticides. Not only do these impacts influence food supply and income but they also play crucial roles in other aspects of farmers lives such as opportunities to send their children to school and the efficiency of providing for their family and community.

Our business proposal provides an analysis and evaluation of implementing a modified underground storage structure, which integrates the use of economical earth bags. To do this we explore concepts such as partnerships established with the Nigerian Stored Products Research Institution (NSPRI) and the employment of a civil engineer. We provide measurements, the materials required and include detailed instructions explaining how to build our underground structure. Comparisons are made with existing models and overall welfare, profitability and sustainability are measured and discussed through our methods of analysis.

This report highlights the primary objective of introducing our proposed offering to minimize threats resulting in production loss, which in turn proves beneficial to farmers, their families and their communities. Limitations are also brought to light where cultural differences and backgrounds can influence the ability of penetrating our market. This venture requires $4550NZD and within the first five years of construction it’s estimated that farmers will have the ability to make increasing profits from stored grains resulting in a return of $1092.27NZD.
Key Challenges of Grain Production

Grains are the most important food staple in the continent of sub-Saharan Africa. For many countries across sub-Saharan Africa, such as Nigeria, the opportunity to grow staple grain crops is fundamental for guaranteeing food for households. This is important because it generates profit and allows the direct consumption of grain crops by small farming villages. The continent produces more than 112 million tons of grain per year while grains themselves account for approximately 37% of income (Fintrac, 2016).

Grain production supports the livelihood of millions of Nigerians in northern regions in which grains are cultivated. In the state of Borno location in Nigeria, many farmers who wish to sell their grains in the Dalwa Market face several challenges that come with producing grains and the damaging effects that can occur during the post-harvest phase. Post-harvest losses happen between the harvest of the grain and the moment of human consumption. These losses occur through various ‘farming to market’ processes such as threshing, drying, storage and transport. In Borno, farmers stated that there are many complications that lead to post-harvest losses such as insect pest infestation (83%), inadequate storage (62%), access to pesticides (58%) and attack by rodents (42%) (Malifiya et al, 2014). Therefore, Inadequate storage makes the crops highly susceptible to these external threats such as attacks from pests and rodents. The detrimental complications grains are exposed to during the post-harvest phase have severe repercussions on the grains themselves. Variations in weight, appearance and the loss of nutritional value are all contributing factors to the loss of profit as lower prices are paid for defective products.

The threat of these damaging conditions force traders to sell their produce immediately after the harvest at market prices which are enviably low. Such low sales deprive these individuals of their legitimate income and they are unable to take advantage of fluctuating market prices after harvest.

Business Overview

Implementing a low-cost storage facility that protects grains from external threats will allow farmers in Borno to be the ones in control of their crops rather than other external parties. Evidence suggests that access to safe, low-cost grain storage technology will provide small farming villages the flexibility to store produced grains for household consumption and sell them when market prices are in their favour (Fintrac, 2016). To combat external threats and provide farmers in Borno with effective storage, our business proposals the construction of an underground earthbag storage structure. Our business will work with a small-scale farming village through the partnerships we establish with the Nigerian Stored Products Research Institution (NSPRI) and the employment of a civil engineer. Employing a civil engineer will directly provide farmers and their communities with the skill and knowledge necessary to efficiently construct effective storage. The knowledge and skills acquired from the civil engineer as well as materials will come at no cost to farmers. The partnership established with NSPRI will benefit our business as we will have extra workers from NSPRI on the construction site while NSPRI benefit as they gain more knowledge for stored products research.

Business Objectives

Our primary objective is to give farmers the knowledge and skills needed to build the underground structures. We hope that through the construction of this storage structure we can empower small-scale farmers, their families and their communities to generate income through farming activities. After this, we hope they are passionate enough about the storage because of the various benefits they have gained that they then pass on their knowledge to other local farmers. This way we also contribute to bringing communities together, and creating of a new flow of critical knowledge that can be passed on from farmer to farmer.
Operations Process

Alongside the civil engineer’s knowledge as well as our we hope to provide farmers the required materials, skill and knowledge to build a functioning underground storage structure. We will work with NSPRI employees and individuals within the farming community through this labour intensive processes to build our underground storage structure.

Materials: To build one underground storage structure of 10m x 8m x 2.4m
Please note All measurements are displayed as (Length x Width x Height) or (Length x Width x Thickness)

1. 696 Polypropylene Silo Bags (1.10m x 75cm)
2. 700 Construction Nails (10 cm): To close the bags and keep the earth in place.
3. 1,000 Construction Nails (6 cm): To join the roofs wood and supports.
4. 50 Wooden Bars (9m x 20cm x 5cm): For the roof.
5. 1 Wooden Block: For the roof.
6. 2 Wooden Bars (2m x 5cm x 5cm): For the door frame.
7. 1 Wooden Bar (1.5m x 5cm x 5cm): For the door frame.
8. 1 Wooden Piece (1.94m x 1.4m x 5cm): For the door.
9. Stainless Steel Door (2m x 1.4m): Thickness must be between 5cm - 50cm: For the tunnel.
10. Supports/Bottomless Buckets: To keep bags open while filling.
11. 220m Steel Wire
12. 2400m Barb Wire
13. Cement
14. Gravel
15. Earth
16. Compactors and Levellers
17. Hammers
18. Wheelbarrows
19. Construction gloves
20. Concrete Screed and Metal Trowel
21. Nail gun
22. Hand Saw
23. Shovel
24. Meter

Steps to Build:

1. Dig a hole in the ground of 14m x 12m x 2.6m (L x W x T). This must have enough space for people outside the construction. Size of the underground storage cellar of this project is: 8m x 10m.

2. To enter the hole while the cellar is built and to leave the space for the tunnel, dig in the direction of the 8m wall where the door will be located.

3. To use the earth from the hole that was dug, it must be separate it from stones and branches.

4. Use the silo bags for wall construction. Use the bottomless buckets to hold the bags and keep them open. Fill 488 bags with slightly moist earth and 162 with gravel. Iron-nails are used to close the bags and keep earth in place. Remember to leave the space for the door in one of the 8m walls. NOTE: The measures found of a filled bag are: 100cm x 65cm x 20cm (L x W x T). The width of the bags equals the thickness of the wall.

5. Make a hole 60cm deep and 65cm wide only where the walls will be located. Fill the hole with the first 3 layers of the gravel bags. This is for drainage and greater stability. Then, add 2m at each edge of the walls (for buttresses), leaving the measures of the wall thus: 12m and 14m (W x L).

6. It is recommended to use buttresses, which allows the wall greater resistance. (This extends the walls more than the limit where it is united with the other walls). These wall extensions diminish as the height of the wall increases. To do it, is recommended to stack the bags as follows (on each buttress):

<table>
<thead>
<tr>
<th>GRAVEL BAGS NEEDED ON EACH KIND OF WALL + BUTTRESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Each 10m wall</td>
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<tr>
<td>Each 8m wall</td>
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<table>
<thead>
<tr>
<th>EARTH BAGS NEEDED ON EACH KIND OF WALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Each 10m wall</td>
</tr>
<tr>
<td>One 8m wall</td>
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<tr>
<td>8m wall with the door</td>
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<table>
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<tbody>
<tr>
<td>Each 10m wall</td>
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To save material, you can take the remaining part of the 60cm bags and use it in the 20cm bags. Since both ends would be open, close one with wire and use the bag in the same way as the others.

7. After placement, each layer must be tamped with the compactor. Make sure that the bags are level in both directions (width wise and length wise). Use the levellers to do it. Between each layer of bags place barb wire to prevent them from slipping.

8. The door may be made of wood, it must be constructed after the gravel bag layers. Place 2 earthbag columns on the doors wood, as in the rest of the structure. For the proposed model, the door dimensions will be 1.50m wide and 2m high, to give capacity to enter and exit for 2 people. Due to these dimensions, it is necessary to place 2 small columns of soil bags on the door: one with 2 bags of 100 cm and 2 bags of 50 cm. This is done to fit the height of this section with the rest of the structure.

9. When the walls are built, use steel wire to cover them to let an easy grip of concrete and achieve a firmer structure.

10. Make a solid concrete base in the underground’s storage structure floor. It is recommended that the depth of the floor be 12 cm to support the weight of the entire structure. In addition, cover the walls with concrete to give a uniform appearance and reinforce the stability of the structure.

11. To construct the flat roof, it is necessary to build a wooden base (supports) that holds the wooden bars that will serve as the roof. 50 supports should be built. To build them: cut 3 sheets of wood 30cm x 20cm (L x W) and 2 rectangular blocks of 20cm x 5cm x 5cm (Lx W x T). Then nail a block of wood along with a sheet (width wise) ensuring that they are level and even. Repeat with the other block and sheet.

12. Put the sheets (on the side that do not have the block) on the excess sheet at a distance of 10cm and nails. Repeat the same procedure to the other 49 supports.

13. Place the supports with a separation of 10 cm each other, fixing the edges in the wooden structures that are placed in the upper limit of the earthbag walls.

14. The wooden bases will be 9m long, to be able to attach each end to the earthbags of the walls. They will have a width of 20cm and a thickness of 5cm. It takes 50 wooden bases to build the entire roof.

15. The tunnel will be (10m x 1.6m x 2m) (L x W x H) and the walls will be 10 columns of 10 layers of bags. To build the walls, fill the bags of the three first layers with gravel, and the rest of the bags will be filled with earth.

16. Starting from the door, is required to put the first bag of each next column 20cm taller than the last column (that is the same height of the bags), so the wall rises to the level of the floor. Then put the stainless-steel door at the end of the tunnel and cover the walls with concrete.
17. The entrance tunnel will be made in the form of a descending ramp, with a slope of 20% considering the maximum height (2m) and the maximum length (10m). This will be covered with a layer of concrete of 10 cm.

18. For the tunnel roof, fill the voids between the soil bags at the top of the wall (from the beginning of one bag to the beginning of the other, diagonally), to leave flat bases to place the wood roof in the same way as placed in the cellar.

19. When all the construction is done and the concrete is dry, cover the leftover parts with the earth that was previously dug.

Market and Marketing Strategies

Target Market

Based on the volume of grain yield that is produced, Dalwa West, Borno state is an appropriate market as one of the main challenges is inadequate storage. Our business will concentrate on Dalwa West, where majority of the farmers are involved with grains. We will specifically focus our primary target market on farmers who fall in the age range of 25-45 (82%), have no formal education (52%), 10-19 years of farming experience (58%) and motivated by the welfare of their families and on a larger scale, their community (Malifiya et al, 2014). Additionally, through strategically targeting this sector of the market and equipping farmers with the tools, skill set and knowledge of building the selected foundation, we remove the ruthless profit-oriented outlook, where if company owned, companies would have the ability to invest, divest, start up, close storage structures at a whim based on the benefits and profits that these structures may provide. It is tailored to meet specific needs of farmers, their families and community.

Competitor Analysis

Our main competition within our market sector is the existing models of underground storage structures. These structures take form of ‘mud rhombus, thatched rhombus, underground pit, and earthen pot and warehouse storage’. (Adejumo & Raji, 2007). We have incorporated the use of earthbags in our approached model ascertaining advantageous through differentiating our product by minimizing current underground structural problems with insects and rodents. Furthermore, earthbags are applicable, doesn’t require special knowledge and overall economical.
Marketing Objectives

Highlight the importance of providing not only a product but also a service that could be passed on with the main goal of overall betterment within families and communities.

Identify the importance of implementing our underground storage structure as it maintains its competitive advantage using earthbags, minimizing existing problems.

Aim to achieve market share and hopefully lead the market by facilitating the growth of initially Bornos agricultural sector with the long-term goal of taking it globally.

Marketing Strategy

Direct Strategy Approach: In every northern community of Nigeria, the Seriki (traditional head), is always in control of every activity that is carried out within the community. This is particularly enforced when introducing an innovative invention because whether the people or farmers will accept our proposal depends on the Seriki. To fulfil our marketing objectives, our business must first pay homage to the Seriki in his home. By explaining what we want to do and that we have been partnered with the NSPRI will allow us to be perceived as reliable since we are backed by such an institute. Once the Seriki accepts us, engaging our target farmers becomes simple. The Seriki will send for them and we will also speak and convince them.

Media Strategy Approach: To promote our structures to reach more than just single communities we will organise radio advertising. This is a cost-effective strategy that will raise awareness of our marketing objectives. We will broadcast our advertisement on 5 radio stations in Borno which is a part of Maiduguri broadcasting zone.

Economic Analysis

As explained in our business overview the costs of materials, skill and knowledge come at no cost to the farmers and their communities. For our business to begin construction we must raise ₦1004000 (this figure has been presented in Nigerian Naira and is equivalent to $4550NZD) to pay for our expenses. Through a combination of crowdfunding and fundraising we plan to acquire the capital needed to begin construction. These activities will allow us to provide insight to those from around the world of the impacts of inadequate storage and what we can offer to those affected. Our business challenges traditional profit-orientated businesses as our main objective is to show how a small-scale farm can receive long-term economic benefits while we take minimal returns. In our economic analysis, it was important to show the spill over benefit incurred following the years of construction between our business and the farm in which the storage was built. Our storage will provide increasing profit for farmers due to less food spoilage, increased production during peak times and higher prices that are paid for grains during off season. This is what our cost benefit analysis focuses on as our business then takes a 25% profit of the extra revenue earnt from the grains that were kept in our built storage. This spill over benefit continues as years go on.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Without Storage</th>
<th>With Storage</th>
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<tbody>
<tr>
<td>Grain Price ₦/Tonne</td>
<td>140000</td>
<td></td>
</tr>
<tr>
<td>Grain Harvested per Farm per Year in Tonnes</td>
<td>3.20</td>
<td>20% Increase</td>
</tr>
<tr>
<td>Grain Sold per Farm per Year in Tonnes</td>
<td>2.20</td>
<td>20% Increase</td>
</tr>
<tr>
<td>Grain Kept in Storage per Farm per Year in Tonnes</td>
<td>0</td>
<td>20% Increase</td>
</tr>
</tbody>
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Future Outlook

This project will initially be carried out in the state of Borno, Nigeria. Home to many farmers in the region who carry out the project to not only improve their lives but those of their entire community. With this project, we can improve the lives of millions of people since this state has more than 4 million inhabitants. A future objective is to expand it to all those farmers interested in improving the quality of their products and life at a low price. As farmers implement our storage they will convey their newly found knowledge to others who can then adopt the idea themselves. Due to its low complexity and easy installation, our storages are appropriate in adapting to different types of needs. This could be done through the communication of our idea via farmers who have had first hand experiences of the storage. They will contribute in the early and easy acquisition of the materials and with the correct adaptation of the project to the individual needs of each farm and farmer. In this sense, the farmers who carry out the project should have the talent to promote it and inexperienced farmers have the opportunity to visit new storages and discover their benefits and functionalities.

Finally, it is necessary to say that although this project is aimed at farmers in Nigeria, it can be applied anywhere in the world. Many food producing countries are affected by this situation, not only in Africa but also in much of Asia and Latin America. Due to this technology's easy adaptability as mentioned above, it become involved with other social problems apart from agriculture, such as housing. However, to achieve the objectives set by the long-term project, it is required that those who carry them out are willing to share knowledge.
References


