The Potential of Bt Cotton Production in Zambia: Profitability, Stakeholders’ Perceptions, and Constraints for Adoption

by

Stephen Kabwe and Bbebe Nchimunya

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Indaba Agricultural Policy Research Institute (IAPRI)

Lusaka, Zambia
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EXECUTIVE SUMMARY

Cotton production started a long time in Zambia, but productivity remains low. The low productivity is despite considerable investments in research and extension by the government and private sector over the years. Among the major contributing factors to low productivity is the lack of optimal control of insect pests such as bollworms and sucking pests among others. Pesticides have been used to control insect pests and over the years, cotton growers have increased the use of these pesticides to control bollworms. Continual use of these chemicals poses a huge health hazard. Can Bt cotton be an answer to these problems cotton farmers are facing in Zambia? The literature on technology advances in cotton production has helped to solve problems of incidences of bollworms damage, which has resulted in increased yield, the profitability of cotton production and reduced the risk to pesticide exposure. Successes in other African countries have motivated cotton stakeholders in Zambia to vigorously advocate for the introduction of Bt cotton in Zambia as part of the solution to the bollworm management problem to improve productivity and farm profitability.

An ex-ante analysis approach was used to assess the profitability of Bt cotton if Zambian farmers adopted the technology and the perception of the major cotton stakeholders on Bt cotton. It further highlights the various challenges that have hindered the introduction of Bt cotton in Zambia. It highlights how these challenges have been or were sorted out in countries that have adopted and commercialized Bt cotton.

This study highlights four major findings

1. If Zambia adopted Bt cotton, it would result in positive additional net benefits per farmer averaging US$60 per hectare. The net benefits are higher for farmers cultivating smaller pieces of land than farmers cultivating larger pieces of land. The higher net benefits are mainly due to higher calculated yields for those cultivating smaller fields than those cultivating larger fields.

2. The experience in other African countries where farmers have adopted Bt cotton achieved on average 28% yield advantage and 46% insecticide cost reduction advantage. If Zambian farmers achieved the same rates after adopting Bt cotton, cotton farming would not be attractive because of the additional net benefit per hectare (US$60) is relatively low compared to other countries. This low benefit is mainly because of low productivity currently experienced by Zambian farmers. Doubling and tripling the net benefits would require yield to increase by 97% and 167% respectively from the current average of 850 kg/ha. Fortunately, these yield increases are achievable in Zambia as a small proportion of farmers are already achieving them.

3. Key informants indicated that divergence views among stakeholders especially proponents of Genetically Modified Organism GMOs and those against the technology create confusion among the policy makers and the general public because they never agree to provide a factual account of the risks associated with such technology for a crop such as cotton. The divergence view of the point has resulted in the government not to be very keen to explore the advantages of introducing Bt Cotton in Zambia. However, more recently, the Government has made some strides in providing an enabling environment for introduction of any GMO by formulating the policy, regulations, and the formation of National Biosafety Authority (NBA).

4. Creation of a platform where to freely discuss GMO issues could help dispel any myths and misconceptions different stakeholders have over GMOs. Reviewing and aligning the Zambian Biosafety regulation especially the liability and redress clauses (who pays for damages as a result of using biotechnology clauses) with the Cartagena
Protocol on liability and redress clauses can help to diffuse the punitive nature of the regulation.

5. Stakeholders need to work on ways that are likely to improve the productivity of seed cotton as the current level of productivity in seed cotton makes the technology look unattractive. Moreover, if the country decided to adopt the technology, it has to do it step by step through confined field trials to assess the performance of the Bt cotton technology before going commercial.
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1. INTRODUCTION

Modern biotechnology is a technique used to isolate, select, and transfer beneficial genes from one organism to another through a process called genetic engineering (Otunge and Muchiri 2010). Genetically modified cotton is engineered through that same process with the view to improve crop performance in one or more traits. Two major types of genetically modified cotton have been developed and exploited globally. One type of genetic modification results in cotton varieties that are resistant to glyphosate-based herbicides such as Roundup, while the other stimulates the cotton plant to produce a toxin that kills the bollworm, one of the crop’s most devastating pests (Perlak et al. 1990) and very common among Zambian cotton producers. Of the two types of genetically modified cotton, insect resistant cotton (Bt cotton) is the most widely adopted and it is the focus of this paper.

The success stories of Bt cotton in various countries are similar. The stories have highlighted increased yields, reduced pesticide use, less tillage, and enhanced worker safety due to some of the benefits obtained after the adoption of genetically modified cotton (ICAC 2013). Studies from some less developed countries, where they have commercially adopted Bt cotton, show encouraging results on adoption rates and economic indicators. Results show that the adoption of Bt cotton is on the rise in countries that have commercialized the production of the crop. For example, adoption rates of Bt cotton in India is over 95% while in China adoption among cotton farmers rates is over 96% while in Africa, South Africa, Burkina Faso and Sudan that have commercialized have continued to make steady adoption rates (James 2015, Choudhary and Gaur 2015). It has also been documented that the use of Bt cotton leads to less expenditure on insecticides and increased yield and profits in cotton production (Vitale et al. 2010; Mulwa, Wafula, and Karembu 2013; Cabinalla et al. 2004; James 2002; Gouse, Kirsten, and Jenkins 2002). Furthermore, other studies show minimized incidences of chemical poisoning among cotton farmers (James 2002).

Cotton is one of Zambia’s most important smallholder cash crops. Improving the productivity and profitability of cotton, therefore, offers significant potential livelihoods benefits for smallholder households. Zambia’s cotton productivity is around 850 kg/ha, and this is lower compared to cotton productivity from West African countries which is over 1,000 kg/ha (Kabwe 2012; Chita 2010). The genetic potential of cotton varieties in Zambia is well above 2,000 kg/ha. Low productivity is caused partly by bollworm damage. Three to twelve sprays of insecticides are done to control bollworms and sucking pests per season. In most cases, farmers use the calendar spray regime, which requires on average eight sprays per season (November 2015. Interview with M. Chigikwa, Mazabuka, Southern Province, Zambia on bollworms in cotton.) With these sprays, cotton farmers incur high insecticide costs, labor costs, and increased risk of chemical poisoning.

Despite developing a biosafety regulation and policy framework, Zambia has not taken concrete steps to introduce the Bt cotton technology. The continued reluctance of the government to present the technology is due to perceived potential negative environmental, health and social effects of the technology.

Behind this background, this study is done to examine the potential benefits and costs of Bt cotton adoption by smallholder farmers in Zambia. To do this successfully, the study addressed three main issues: 1) used yield gain and labour increase rates, insecticide and labour cost reduction rates from other countries to assess the profitability of Bt cotton if Zambian farmers adopted the technology; 2) ascertained the yield required for Zambia’s cotton sector if they needed to double or triple the net benefits after adopting Bt cotton; and 3) lastly, review of perception of Bt cotton of cotton stakeholders in Zambia.
The remainder of the paper is divided as follows. Section II is a review of potential benefits and negative impacts of Bt cotton adoption. Section III describes the data, methods, and the analytical framework for our analysis. Section IV presents the results, and Section V presents a set of conclusions, and Section VI highlights the recommendations of the study.
2. IMPACTS OF BT COTTON ADOPTION: A REVIEW OF EXPERIENCES

Commercial application of modern biotechnology, which brought about genetically modified organisms (GMOs), started in 1996. Since then, there has been increasing interest globally in the use of this technology to serve as a vehicle for sustained improvement in crop productivity. Currently, genetically modified crop varieties are grown in 29 countries with an estimated total area of 170 million hectares and involving more than 18 million farmers (James 2015).

As indicated above, genetically modified cotton is one of the most widely adopted biotechnologies in the world. For instance, in 2013, the global share of GM cotton hectarage stood at 70% (James 2015).

In Africa, adoption of GMOs is low, but some African countries have carried out trials, and some have even gone as far as commercializing the technology. Burkina Faso, where almost 100% of cotton production is by smallholder farmers, approved the commercial cultivation of Bt cotton in 2008. By 2011, studies indicated that the average yield for Bt cotton was 19.7% higher than conventional cotton in Burkina Faso. Apart from increased yield, spraying was reduced from 6 to 2 (James 2012). According to Brookes and Barfoot (2014), enhanced farm income from biotech crops in Burkina Faso during the period 2007 to 2012 was estimated to be US$ 187 million. Although the general Bt cotton picture in Burkina Faso is positive, there have been concerns about the reduced quality of cotton produced in that country after the introduction of Bt cotton. The problem is due to varietal mixtures that pre-existed before the introduction of Bt gene to cotton (December, day 2015 interview on the Experience of Bt Cotton in Burkina Faso while at ICAC Plenary meeting in Mumbai, India with Mr. Traore, Permanent Secretary, Ministry of Agriculture, Burkina Faso).

South Africa, which has a greater proportion of cotton production done by commercial farmers, adopted Bt cotton in 1998. Reports on the yield and livelihood impact of the technology have varied. According to Ishmael, Bennet, and Morse (2002), Bt cotton had a yield advantage among smallholder farmers of between 18% to 60% during the period between 1998/99 and 2000/01. Furthermore, the cost of insecticide reduced between 13% and 38%. Morse and Bennet (2008) also reported positive benefits from Bt cotton adoption by smallholders in South Africa. Most adopters (76%) reported having increased their seed cotton yields, which helped increase their incomes. Brookes and Barfoot (2014) established that the main impact of Bt cotton in South Africa had been significantly higher yields that rose 24%. On the other hand, the additional cost of Bollgard1 I and Bollgard II (2006 onwards) was greater than the insecticide cost and labor. The increase in extra costs resulted from an increase in overall cost of production of $2/ha to $32/ha, but the enhanced yield advantage offset the overall costs.

India, where more than 77% of the cotton area is under smallholders, has been commercially growing Bt cotton since 2002. Since then, the hectarage under Bt cotton has increased to more than 90% of the total cotton area (James 2015). Kathage and Qaim (2012) through a study established that Bt cotton in India had resulted in 24% improvement in cotton yields, 50% gain in profitability, and 18% increase in consumption expenditure among small-scale cotton growers during the 2006-2008 period. Brookes and Barfoot (2014) established that on average, the cost of the technology (seed premium: $49/ha to $54/ha) in 2006 was bigger than the average insecticide cost savings of $31/ha-$58/ha and resulted in a net increase in costs of

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1 Bollgard (I & II) cotton is a name of the first Bt cotton genes, which are cotton proteins for effective control of the major lepidopteran insects pests of cotton (bollworms, pink bollworms, and army worms) (Monsanto 2003).
production. Following the reduction in the seed premium in 2006 to about $20/ha, farmers realized $20/ha-$25/ha net cost saving. On the other hand, the farm income gain at the national level in 2012 was $2.1 billion (Brookes and Barfoot 2014). Discussions with scientists from Central India Cotton Research (CICR) at the 74th plenary meeting of the International Cotton Advisory Committee (ICAC) in Mumbai indicated that over 85% of the area of cotton is under Bt cotton. Productivity is around 500 kg of lint/ha from 300 kg of lint/ha before the adoption of Bt cotton. Productivity has stagnated around 500 kg of lint/ha. Lack of research initiatives resulted to stagnation in improving productivity in Bt cotton. However, CICR has initiated some new research technologies to enhance productivity such as High-Density Production Systems (HDPS) (Interview on 4, December 2015 on the Experience of Bt Cotton in India while at ICAC Plenary meeting in Mumbai, India with Dr. M.V. Venugopalan, Principal Scientist, Central Institute for Cotton Research of India).

China, with more than 100,000 smallholder cotton farmers, adopted genetically modified Bt cotton in 1997 (Pray et al. 2001). Since then some studies have been instituted to establish the economic impact of Bt cotton in China (Huang et al. 2002; Pray et al. 2001). By 2012, China had planted Bt cotton on 80% of total national cotton hectarage (Brookes and Barfoot 2014). The same study highlighted an increase in yield rate between 8% and 10% which enhanced income impact. Furthermore, there have also been significant cost savings on insecticides used and the labour. Overall, average annual costs have fallen by about $145/ha-$200/ha and average annual profitability improved by $123/ha-$559/ha. Cumulatively, since 1997 the farm income benefit has been $15.27 billion (Brookes and Barfoot 2014).

Cotton production in Brazil concentrates on large farms averaging 2,000 ha. Bt cotton commercial production first started in Brazil in 2006 and by 2012, the country had planted 212,770 ha of Bt cotton, which was 24% of the total crop (Brookes and Barfoot 2014). Despite this increase, the yield performance of the varieties containing genetically modified insect resistant traits was lower (by 2.7% to -3.8%) than the leading non-Bt cotton varieties available between 2007 and 2009 (Galveo 2010). In given this and taking into consideration insecticide cost savings and the seed premium, the average impact on farm income has been negative. At the country level, this resulted in aggregate net losses in 2007 and 2009 from using the technology, e.g., -$5 million in 2009 (Brookes and Barfoot 2014).

Argentina started commercial Bt cotton production in 1998. The average farm size in Argentina is between 10 ha and 20 ha. In 2014, Bt cotton accounted for 100% of total cotton plantings (Brookes and Barfoot 2014). The main impact of Bt cotton has been yield improvement of 30% and gross margins at farm level of US$25/ha and US$249/ha per annum during the 1998-2012 period (Brookes and Barfoot 2014). The average volume of insecticide used by Bt cotton growers is 44% lower than for conventional cotton growers (Qaim and De Janvry 2005).

Although some studies on Bt cotton impact show significant positive results, other studies point to a negative impact of Bt cotton. Xue (2002) reported that Bt cotton tends to hurt the survival of soil microorganisms. Kranthi (2011) indicated that Bt cotton hybrids had more nutrient and water requirements than conventional hybrids. Sahai and Rahaman (2003), and Shiva and Jafri (2004) have reported that the performance of Bt cotton was worse than non-Bt cotton both in yields and quality in India. Qaim et al. (2006) indicated that Bt cotton technology might not be appropriate for all producers because pest pressure and access to other control measures vary from producer to producer who have different management skill and capacity. Those who do not benefit eventually abandon the technology, while the rest continue.
Despite some areas of concern regarding income effects, there have been overall positive trends in the adoption rates of the Bt cotton technology worldwide. For example, by 2008, Bt cotton represented 46% of global cotton production. In 2010, about 21 million ha of Bt cotton were planted, representing almost two-thirds (64%) of 33 million hectares of world cotton cultivation (James 2011). As of 2015, area of cotton under GMO cotton has reached about 70% (James 2015). Looking at specific developing countries, the area of cotton under Bt cotton in India and Burkina Faso is about 80%. In South Africa, within four years of its introduction, the adoption rate of Bt cotton rose from 2.5% to almost 90%. These trends suggest that Zambia needs to take notice and try to understand the implications of the Bt cotton to smallholder farmers faced with high cotton insect pest prevalence, low productivity, and profitability. Would Zambia be able to compete with Bt cotton producing countries and at the same time be able to keep cotton farmers motivated to produce the commodity?
3. DATA AND METHODS

The study used mixed methods to examine the profitability and perception of Bt introduction in Zambia. The methods include quantitative and qualitative. These methods complement each in triangulating the research results and are discussed in more details in the next section.

3.1. Data

The quantitative data used in the analysis of the partial budget came from the Rural Agricultural Livelihood Survey (RALS) 2015 conducted by IAPRI in conjunction with the Ministry of Agriculture and Livestock and Central Statistics Office in June/July 2015. RALS 2015 covered the 2013/14 agricultural year, and the 2014/15 crop-marketing year. RALS data is nationally representative and focused on small-scale farmers in all ten provinces of Zambia. For more details about the survey see 2016 RALS report (Chapoto and Zulu-Mbata 2016). However, we restrict our sample to cotton-growing provinces only, Central, Eastern, Lusaka and Southern provinces. We categorize the cotton farmers into five categories by the area cultivated and this is based on the RALS report 2016² (Chapoto and Zulu-Mbata 2016). The data compiled from RALS include actual cotton yield, seed rate per hectare and average area cultivated (ha). Also, the study drew yield advantage, insecticide cost advantage and labour cost advantage information from Bt cotton studies done from other developing countries (e.g., Ezezika, Barber, and Daar 2012; Vitale et al. 2010; Morse, Bennett, and Ismael 2004; Bennett et al. 2003). We converted all the costs and income values to U.S. dollar currency. The Bank of Zambia website was a source of the average exchange rate for 2013/14 at two periods (production and marketing period of seed cotton).

Furthermore, we conducted interviews with the principal informants (operation managers, cotton extension officials, and lead farmers) to collect the information on the cost of inputs (seed, chemicals) and cost of labour per hectare. We also captured the perception of the benefits and disadvantages of Bt cotton from the stakeholders. Furthermore, we sourced information on the prevalence of insects such as bollworms, leaf eating, and sucking insects.

3.2. Methods

This paper provides an ex-ante analysis of the potential benefits from Bt-cotton if farmers in Zambia adopted the technology using a partial budget analysis approach. The study also used key informant interviews to ascertain the perceptions of key stakeholders on Bt cotton. Specifically, the study attempted to answer the question whether farmers in Zambia would be better or worse off to grow Bt cotton. The introduction of the technology can affect some components of the farm budget. Since all components of the farm budget that are not affected by the proposed change will remain constant, a complete farm budget is not needed to determine the profitability of these specific shifts in the operation of the farm. In this case, it is recommended to analyze only those costs and incomes that change with a proposed business adjustment (Pitoro 2004; Dalsted and Gutierrez 1990). The study used a partial budget approach to analyzing the net benefits where we only considered the relevant costs and incomes that vary. The partial budget contains benefits and costs classified in four categories as described by Dalsted and Gutierrez (1990): additional income, reduced cost, reduced income, and additional costs. Since Zambian farmers have not yet adopted Bt cotton, we considered the assumptions about the technology. These assumptions are Bt cotton seed

² Cotton farmers cultivating less than 0.5ha=1, those cultivating 0.5ha to less than 1ha=2, those cultivating 1ha to less than 2ha=3, those cultivating 2ha to less than 5ha=4 and those cultivating 5ha or more=5.
prices (technology fee), yields, insecticide costs advantage and labour cost advantage rates drawn from various reports (Ezezika, Barber, and Daar 2012; Vitale et al. 2010; Morse, Bennett, and Ismael 2004; Bennett et al. 2003).

3.3. Definitions of Some Terms for the Partial Budget Analysis

3.3.1. Benefits

Since Bt cotton reduces costs of pesticide, this constitutes a benefit. We evaluated the reduced pesticide costs by assessing the cost of each saved insecticide application by using Bt cottonseed. In the analysis, we considered an average (46%) cost reduction advantage if one adopted Bt cotton from various studies (Vitale et al. 2010; Morse, Bennett, and Ismael 2004). Another benefit from adopting Bt cotton is a reduction of labor used in insecticide application. For this analysis, we evaluated labor at the actual wage rate, Zambian Kwacha (ZMW) 40 or US$ 6.83 per spray. Given that there is no price difference between Bt cotton and conventionally produced cotton, we used the farm gate price of conventional seed cotton paid to the farmers in 2015/16 marketing season. In this regard, we used ZMW 2.5 or US$0.39 per kg of seed cotton. The additional income and reduced costs have a positive effect on net income, and their sum would indicate the total additional benefits.

3.3.2. Costs

Companies such as Monsanto and Syngenta have developed Bt cotton technology. The introduction of the Bt cotton technology is through local varieties, or the Bt cotton developing company may bring new varieties with a Bt technology. However, it is advisable to add the Bt cotton technology into the well performing local varieties. Farmers pay a licensing fee for using the technology. Currently, the fee is around US$20 per hectare (James 2014). The additional labour required due to increased yield would result in additional cost. We assume 46% labour increased.

As a requirement, farmers also have to incur a cost of planting a refuge crop, which is required to help prevent or delay the emergence of resistance to the Bt gene. Normally the cost is evaluated as the yield difference of the unsprayed cotton lost and the Bt cotton and takes between 5% and 20% of the total area for a mono-Bt trait variety (ISAAA 2015). In this study, we adopted the 15% of the total area for a mono-Bt trait variety to determine the refuge cost and translated in cost would be around US$7 per hectare (Pitoro et al. 2009). Since no reduced income factor is foreseen, the total cost will be constituted only by total additional costs.

3.3.3. Net Income

We determine the effect of the proposed change on net income by comparing the sum of additional income and reduced costs with the sum of reduced income and additional costs (Lessley and Johnson 1991). If the additional income and reduced costs (benefits) are greater than the reduced income and additional costs (costs), then production of Bt cotton will increase net income to farmer compared to the production of conventional cotton. Gittinger (1982) and Belli et al. (2001) argue that financial and economic costs/benefits differ when

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3 Using the exchange rate for the production season September 2013 to August 2014 of (US$1=ZMW5.9) and marketing period of May 2014 to February 2015 of (US$1=ZMW6.4)
there is a market distortion caused either by government policy. The financial costs/ benefits are those financially observable by any participants in the production process, whereas the economic benefits are not directly observable, and appear as a way to correct for market distortions.

In our analysis, we adjusted the Bt cotton yield data from the conventional yield data. We used an average yield rate of 28% adapted from studies from Burkina Faso and South Africa (Ezezika, Barber, and Daar 2012; Vitale et al. 2010; Morse, Bennett, and Ismael 2004; Bennett et al. 2003). To see how sensitive the results were, we assumed doubling and tripling net benefits and estimated the base yield of conventional cotton production.
4. RESULTS

We present the results of this study in two parts. The first part highlights the results from the key informant interviews while the second sub-section shows the results of the partial budget analysis.

4.1. Perception of Bt Cotton by Stakeholders

Knowledge of any technology is critical for making an informed decision on the adoption or disadoption of the technology. All the key informants talked to, are aware of the Bt cotton technology and potential benefits and costs (see Appendix I for the list of respondents). However, the views about the introduction of the technology into the country depended mostly on the institution the respondent was representing. Only two (2) institutions out of fourteen interviewed were opposed to the introduction of Bt cotton in Zambia. These institutions indicated that adoption of the technology would not be good for the country as it would compromise plant biodiversity. It was further pointed out that there can be a loss of the original cotton varieties if Bt cotton was adopted. However, literature shows that commercialized genetically modified crops have reduced the impacts of agriculture on biodiversity, through enhanced adoption of conservation tillage practices, reduction of insecticide use and use of more environmentally benign herbicides and increasing yield to alleviate pressure to convert additional land into agricultural purposes (Carpenter 2011).

Another concern raised by one respondent from a ginning company was lint quality. It was indicated that the industry was not against the Bt cotton but cited possible lint quality issues currently experienced in Burkina Faso after the introduction of Bt cotton as a major concern. The research team interviewed the Permanent Secretary in the Ministry of Agriculture of Burkina Faso to learn more about the concerns during the 2015 International Cotton Advisory Committee (ICAC) in India. The Permanent Secretary attributed the problem of quality of lint to cottonseed varietal mixtures that pre-existed before the introduction of Bt cotton gene (Interview on 8, December 2015 with Dr. M.V. Venugopalan, Principal Scientist, Central Institute for Cotton Research of India on the Experience of Bt Cotton in India while at ICAC Plenary meeting in Mumbai, India).

Five out of 14 informants interviewed indicated that the opinion among scientists was divided and that had complicated the introduction of GMO technology in the country. Given divided opinions among scientists requires clarification in as far as the safety and sustainability of the technology.

Those that supported the introduction of the technology indicated that Zambia was not an island and could not shy away from discussing or even adopting the GMO technology especially the none food such as Bt cotton. They argued that the technology could be suitable for the smallholder farmers in Zambia as it would sort out the problem of bollworms, reduce the number of chemical sprays, and reduce the cost of chemicals. Eventually, the adoption of GMO cotton can improve the productivity of cotton farmers. A further benefit associated with adoption of GMO cotton is a reduction in farmers’ exposure to toxic pesticides. Also, GMO cotton could help to reduce the cost of weeding if GMO cotton was bred to tolerate non-selective herbicides. With unpredictable weather and changing climate conditions, GMO cotton was cited as an important solution to impacts of climate change in cotton production especially if scientists breed a cotton variety with a gene that can withstand the water stress and can mature early.
Other aspects highlighted were that the Bt cotton technology was meant to target only one type of pest. If other pests apart from bollworms would become problematic, then the technology could be rendered irrelevant if no other control measures are considered.

Review of literature shows that the primary function of Bt cotton is to control the bollworms infestation on cotton (Vannila, Sabesh, and Banbawale 2007). Yield enhancement comes in as secondary benefits after controlling bollworm infestation. Therefore, other aspects of improving cotton yields have to be adhered to by the farmers to maximize the benefit of the technology. Looking at the current productivity levels of cotton of 850 kg/ha of seed cotton against the 2,500 kg/ha varietal potential only shows that farmers need to adopt good farming practices to improve yield before the adopting the Bt cotton technology for them to maximize its benefits. Some key informants interviewed echoed similar sentiments to improve cotton productivity before the Bt cotton technology was introduced if cotton farmers were to realize maximum benefits. Stakeholders cited little sensitization about the technology them. With little information disseminated about the benefit and risks of the technology, people tend to be apprehensive in accepting the technology in the country.

Also, respondents indicated being aware of the biosafety regulation Zambia has developed but pointed out that the law had not been disseminated widely to the public for them to appreciate its content.

Key informants indicated that Zambia is faced with the problem of bollworms, leaf eating, and sucking insects as per Table 1. It was reported that the prevalence of these insects was high in cotton-growing provinces (Central, Eastern, Lusaka, and Southern Provinces).

### Table 1. Common Cotton Pests Found in Zambia

<table>
<thead>
<tr>
<th>Types of insects/pests</th>
<th>Insects/pest common</th>
<th>Prevalence</th>
<th>Spraying Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bollworms and other lepidopterans insects</td>
<td>- Africa/American Bollworm, - Red bollworm, and - Spine bollworm</td>
<td>High</td>
<td>Eight times per calendar regime</td>
</tr>
<tr>
<td>Leaf-eating/caterpillars</td>
<td>- Green caterpillars, and - Grasshoppers</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Sucking Insects</td>
<td>- Aphids, and - Jassids</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

Source: Retrieved in September, 2016 from Pest in Cotton website: https://www.google.co.zm/search?q=pests+in+cotton&biw=1517&bih=681&tbnid=isch&tbo=u&source=univ&s a=X&sei=2&ved=0ahUKEwjrkOuJyJvPAhVLKMAHixDNEQ7AkIQQw&dpr=0.9
To control these insects, the farmers spray chemicals eight times as per calendar regime. Even under Integrated Pest Management where farmers spray as they see insects, the number of sprays varies from 3 to 10 sprays.

4.2. Returns for Bt cotton

Partial budgeting analysis was done to examine the income effect of Bt cotton adoption by smallholder households in Zambia. Five categories of farmers were developed based on the land cultivated using RALS 2015 data. The category with the largest number of cotton farmers is one cultivating less than 0.5 hectares representing 34% of smallholder cotton-producing households. Then the category cultivating 0.5 hectares to less than 1 hectare representing 29% of cotton farmers was second. The category with a fewer number of cotton households (0.7%) is one cultivating 5 hectares or more. If we assume that production of Bt cotton results into 28% yield increase, 46% insecticide costs reduction as per what is achieved in African countries that have commercialized Bt cotton production, Zambian farmers can achieved positive net of US$60 per hectare. The farmers cultivating less than 0.5 hectares would realize the highest net benefits of US$81 per hectare compared to those cultivating 5 hectares or more US$27 per hectare. The net benefit is 196% greater than the latter as shown in Table 2. The difference is due to the yield differences where those cultivating 0.5 hectares obtained 1,418 kg/ha while those which cultivated 5 ha or more produced 638 kg/ha.\(^4\) The results show that there is an inverse relationship between cultivated land and yield. These results are similar results obtained by Gül Ünal 2008 and Thapa 2007 whose findings support the inverse farm productivity relationship.

The results imply that if Bt cotton was introduced in Zambia, the yield and cost performance will be the main factor in shaping the financial gains by cotton farmers. Key informants stressed the need for cotton farmers to improve productivity in cotton production. “Even if the farmers are allowed to grow Bt cotton, as long as the status quo of low productivity among cotton production systems persists, substantial benefit from adoption of Bt cotton by the farmers cannot be realized.” (From interview with the Secretary to the Cotton Board of Zambia in October 2015 on the prospects of introducing Bt cotton in Zambia. Lusaka, Zambia.)

---

\(^4\) There is an inverse relationship between area cultivated and productivity. Farmers with smaller fields tend to have higher yields than those with larger fields.
Table 2. Financial Analysis of the Expected profitability of Bt Cotton in Zambia

<table>
<thead>
<tr>
<th>#</th>
<th>Variables</th>
<th>less than 0.5ha</th>
<th>0.5ha - &lt;1ha</th>
<th>1ha - &lt;2ha</th>
<th>2ha - &lt;5ha</th>
<th>5ha or more</th>
<th>National avg. 0.8ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Percent of cotton households by land category (170,714)</td>
<td>33.7</td>
<td>29.1</td>
<td>27.2</td>
<td>9.3</td>
<td>0.7</td>
<td>100.0</td>
</tr>
<tr>
<td>B</td>
<td>Average area (ha)</td>
<td>0.4</td>
<td>0.8</td>
<td>1.0</td>
<td>2.0</td>
<td>6.0</td>
<td>0.8</td>
</tr>
<tr>
<td>C</td>
<td>Additional Yield (kg/ha)</td>
<td>307.0</td>
<td>238.8</td>
<td>191.0</td>
<td>164.4</td>
<td>138.2</td>
<td>238.8</td>
</tr>
<tr>
<td>D</td>
<td>Additional benefits (US$/ha)</td>
<td>130.9</td>
<td>101.8</td>
<td>81.5</td>
<td>70.1</td>
<td>58.9</td>
<td>101.8</td>
</tr>
<tr>
<td>E</td>
<td>Savings in insecticide costs (US$/ha)</td>
<td>25</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>Total additional benefits (US$/ha)</td>
<td>156</td>
<td>122</td>
<td>97</td>
<td>85</td>
<td>74</td>
<td>122</td>
</tr>
<tr>
<td>G</td>
<td>Technology fee of Bt gene (US$/ha)</td>
<td>35.8</td>
<td>29.0</td>
<td>21.7</td>
<td>21.7</td>
<td>20.9</td>
<td>29.0</td>
</tr>
<tr>
<td>H</td>
<td>Increased labour cost due to increased harvest (US$/ha)</td>
<td>32.2</td>
<td>26.1</td>
<td>19.6</td>
<td>19.6</td>
<td>18.8</td>
<td>26.1</td>
</tr>
<tr>
<td>J</td>
<td>Refuge (US$/ha)</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>K</td>
<td>Total additional costs (US$/ha)</td>
<td>75.0</td>
<td>62.1</td>
<td>48.3</td>
<td>48.3</td>
<td>46.7</td>
<td>62.1</td>
</tr>
<tr>
<td>L</td>
<td>Additional net benefits (US$/ha) (F-K)</td>
<td>81.0</td>
<td>60.1</td>
<td>48.4</td>
<td>37.0</td>
<td>26.9</td>
<td>60.1</td>
</tr>
<tr>
<td>M</td>
<td>Additional total net benefits (US$) (I*B)</td>
<td>43.3</td>
<td>65.6</td>
<td>64.1</td>
<td>105.5</td>
<td>251.8</td>
<td>65.6</td>
</tr>
</tbody>
</table>

Source: Author’s computation.

Assumptions
1. Yield for Bt cotton is conventional cotton yield adjusted by 28% based on the studies done in Burkina Faso and South Africa.\(^5\)
2. Cost of Chemicals for bollworms is cost adjusted downwards by 46% based on the studies done in Burkina Faso and South Africa.
3. Increase in harvesting cost by 28% due to an increase in yield
4. Reduced labour cost for insecticide cost by 46%
5. Price of Bt cottonseed is assumed at ZMW14/kg or US$2.2/kg.
6. Five categories generated based on land cultivated as per RALS 2015 report
7. Exchange rate ZMW6.4 to US$1 during production period
8. Exchange rate ZMW5.9 to US$1 during marketing period

\(^5\) Vitale et al. 2010 and Morse, Bennett, Ismael 2004.
Table 3. What Yield Would Warrant Doubling or Tripling Net Benefits (US$/ha)?

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conventional cotton production</th>
<th>Bt Cotton Baseline</th>
<th>Double net benefits</th>
<th>Triple net benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Yield (Bt) (kg/ha)</td>
<td>864</td>
<td>1,103</td>
<td>1,699</td>
<td>2,295</td>
</tr>
<tr>
<td>2 Price of seed cotton (US$/kg)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>3 Gross Benefits (US$/ha)</td>
<td>368</td>
<td>470</td>
<td>724</td>
<td>979</td>
</tr>
<tr>
<td>4 Cost (US$/ha)</td>
<td>195</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>5 Net benefits (US$/ha)</td>
<td>173</td>
<td>254</td>
<td>508</td>
<td>763</td>
</tr>
</tbody>
</table>

Source: Author compilation, for baseline indicators, 28% yield advantage increase, 46% reduction in costs of insecticides was considered.

Given the huge variation in yield and costs, a sensitivity analysis was performed to ascertain the yield that would enable cotton farmers to double or triple the net benefits (US$) per hectare if cotton farmers adopted Bt cotton holding costs constant. Table 3, shows doubled and tripled net benefits US$508 and US$768 from the base net benefits and the subsequent yields of 1,699 kg/ha and 2,295 kg/ha needed to achieve the doubled and tripled net benefits. The question is, are these yields (1,699 kg/ha and 2,295 kg/ha) feasible with the current conventional technologies for cotton farmers in Zambia?

The distribution of cotton yield under conventional among smallholder farmers in Zambia using survey data collected by the Ministry of Agriculture and Central Statistics Office for 2013/14 agricultural season (Figure 2 shows that only about 37% of farmers achieve yields above 1,000 kg/ha. While half of the cotton farmers in Zambia produce 864 kg or less of seed cotton per hectare in Zambia.

The base scenario, using yield and cost rates recorded from Bt experiencing in Africa, do not provide a bright projection for the adoption of Bt cotton in Zambia as the increase in additional net benefits is very minor, US$60 ha. If farmers were to achieve double or triple net benefits under Bt cotton production, the yield would have to increase to at least 1,229 kg and 1,660 kg/ha respectively. Figure 2 shows that about 28% of the cotton farmers get 1,229 kg/ha already, and another 10% get 1,660 kg/ha or above. Higher yields are achievable in Zambia that can make the technology worthwhile in the country, though only for the small percentage of farmers. Given that the majority of cotton producers’ productivity is below that threshold and an average productivity of seed cotton hovers around 850 kg/ha between 2001 and 2014 (Kabwe, Kapembwa Namonje, and Chisanga 2016), there is a need to encourage farmers producing 850 kg/ha or below to adoption of better agronomic practices in order to double or triple production through. This requires that a comprehensive extension package is adopted. Otherwise, adoption of Bt cotton alone, which only focuses on tackling the problem of insects and pests, would not be effective in improving productivity and profits as the technology can only complement other best farming practices adopted by the farmer. Therefore, farmers need to follow other agronomic practices such as doing early land preparation, correct time of planting, correct plant population, and early weeding, wise pest management in order to maximize seed cotton production per unit area (Sekamatte 2016). Above all farmers need to have attitude change towards taking farming as a business.

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6 Considered 28% yield advantage increase, 46% reduction in costs of insecticides
4.3. What Are the Key Issues Hindering the Introduction of Bt Cotton in Zambia?

The debate on the possibility of introducing Biotechnology in crop production in Zambia started in the late 1990s. Since then no biotechnology crops has been introduced in the country even after the enactment of the Biosafety framework in 2007. This section highlights some of the perceived issues that might have hindered the introduction of the biotechnology.

i) The political atmosphere concerning biotechnology. When Zambia experienced a drought in 2002, it resulted in a shortage of the staple food crop maize. The United States of American government wanted to donate GMO maize to the country to avert the looming hunger. However, the late President then, Dr. Patrick Mwanawasa rejected that offer (GMO maize) citing reasons that the country was not ready for biotechnology because by then the country had not developed the Biosafety regulations and also health reasons. In subsequent years after the demise of the President, some politicians have kept that same stance even though the country has developed the Biosafety regulations. With the development of the Biosafety framework, it shows that the Zambia is ready to handle any GMO products including Bt cotton as long as an applicant follows the stipulated laws of the Act.

ii) Divergence views about the biotechnology. There are divergence views from stakeholders concerning the introduction of GMO (Bt cotton included) among stakeholders in Zambia and the world as a whole. For example, the anti-GMO organizations have argued that GM crops like Bt cotton do not offer farmers any yield gain or reduced amount of pesticides use (Greenpeace 2011). Contrary to this view, studies conducted in countries that have adopted the technology have shown a reduction in bollworm attacks and reduced cost of insecticide and yield gain as a result of adoption of Bt cotton (Vitale et al. 2010; Gruere and Sun 2012; Cabanilla, Adbdoulave, and Sanders 2004; James 2002; Gouse, Kirsten, and Jenkins 2002). The reduction in bollworm has also resulted in increased yield (James 2014).

iii) Who pays for damages in case they occur due to the introduction of biotechnology? This clause in the Biosafety Act of Zambia requires that the damages shall be borne by the person who imports, contained use, or and developer of the technology. The
stated clause may inhibit and discourage private sector investment in GMO activities. Article 36 and 45 of the Biosafety Act of Zambia create strict liability for biotech providers, suppliers and developers for any harm including a broad array of damage, injuries or losses ranging from things such as disruption of agriculture systems, to harm to social-cultural conditions, to damage caused by incidents of public disorder. Further, in every legal system, the establishment of a criminal offense, which can be punished by incarceration and other sanctions, is dependent upon the person being found guilty of willful or intentional misconduct.

iv) **Lack of platform to share information about GMO.** Lack of a platform to exchange information about GMO related issues in Zambia has led to misinformation about the biotechnology. Further, there is minimal or lack of engagement with the policy makers to bring them to speed with issues of biotechnology more especially Bt cotton.

v) **Policy concerns:** This includes the fear that multinationals will control the food, feed and seed sectors; fear of loss of trade with Europe; loss of indigenous knowledge systems and ethics. This negative perception does not only come from the anti-GM communities but also from other segments of the society.

vi) **External influence:** especially for countries that support GMOs and those countries that do not support, can create difficulties for the country to decide to introduce biotechnology.

vii) **Awareness and knowledge about the biotechnology in Zambia:** This is very low. A study conducted by Bbebe, Chijikwa, and Kabwe 2014 in Mumbwa, Mazabuka and Sinazongwe shows that over 56% of the cotton farmers have never heard about Bt cotton/GMOs.

viii) **Coordination and competition:** As indicated by Poulton et al. 2004, excessive ginning capacity and side selling can be a threat to the introduction of Bt cotton because the companies may reduce the investment.

**4.4. How Have Countries Where GMO Crops Been Introduced Resolved Some of These Issues?**

Countries such as Burkina Faso, South Africa, and India that had adopted and commercialized the biotechnology experienced similar problems highlighted above before commercializing the technology in their countries. This section highlights what the countries did to sort out some of the challenges they faced based on the studies done by Ezezika, Barber, and Daar 2012; Cooke and Downie 2010.

Engagement of key stakeholders such as politicians, policy makers, farmers and the private sector before and after the introduction of the biotechnology by the developers or scientists was considered as paramount for acceptance of the technology. As a result, the process built trust between the technology developers or scientists and the stakeholders. Burkina Faso used four critical strategies that enabled the country to have Bt cotton project started. The country developed strong collaboration between research, industry, and farmers which in turn fostered trust among partners. The country also developed a strong communication strategy that compiled scientists to communicate promptly the results from the field trials. The development of the strategy enabled the stakeholders to react and get clarification on any issues that arose. India also implemented a similar approach, though India used to organize an annual international conference where Bt cotton stakeholders convened and discussed issues affecting Bt cotton production. The process allowed sorting out issues as they developed before and after the introduction of Bt cotton.
As highlighted, there has been negative perceptions of biotechnology companies (Monsanto, Syngenta, and others) from anti-biotechnology communities and other stakeholders because they feel these companies have different motives. To resolve that issues, the multi-national companies were requested to articulate plainly their motives and risks concerning the technology. Furthermore, Burkina Faso adopted a concept of seeing and believing seminars. The seminars were a communication campaign to dispel popular myths and misconceptions about biotechnology. The seminars also considered the literacy level of stakeholders and therefore, communication materials were translated into local languages to make sure all stakeholders regardless of literacy level were communicated to on issues of biotechnology. All these approaches helped to build the trust of partners.

The Makhathini Bt cotton adoption shares some experience on the importance of higher yield for the varieties even before the introduction of Bt cotton. Results showed that a yield of 500 kgs/ha of seed cotton and low prices of about US$0.19 cents darken the prospects of introducing Bt cotton (Gouse 2006). Therefore, stakeholders had to work on ways of improving productivity for farmers and the sector to remain competitive even after the introduction of Bt cotton.

### 4.5. Zambia’s Biosafety Regulation vs. Some Sub-Saharan Countries Biosafety Regulations?

The Zambian parliament passed the Biosafety Act in April 2007, calling for the establishment of a National Biosafety Authority (NBA) to receive and vet applications for research, development, import, transit, contained use, release, and commercialization for genetically modified organisms. Then government established the permanent secretariat in 2014 to run the affairs of NBA. The legislation lays out mechanisms for liability and redress for any harm or damage caused to human and animal health, non-GMO crops, socioeconomic conditions, and biological diversity. While the bill does not outright ban GMOs, most stakeholders see the legislation as more prohibitive than facilitative of biotechnology research. The review of Zambia, South Africa, Malawi, Sudan, Tanzania and Rwanda’s biosafety regulations and Cartagena Protocol on the liability and redress clauses shows a mixed consideration on who shoulders the responsibility if the damage on human health, animals, socio-economics or/and environment occurred. Table 4 demonstrates the status of the introduction of GMO in each country and also what the liability and redress clause highlights in each country.

<table>
<thead>
<tr>
<th>Table 4. Review of the Liability Clauses of Zambia vs. Some Selected African Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
</tr>
<tr>
<td>Zambia Biosafety</td>
</tr>
<tr>
<td>Country</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Malawi</td>
</tr>
<tr>
<td>South Africa</td>
</tr>
<tr>
<td>Rwanda</td>
</tr>
<tr>
<td>Tanzania</td>
</tr>
<tr>
<td>Sudan</td>
</tr>
</tbody>
</table>

Author’s summary.
Article 5 and subsections 1 to 8 of the Supplementary Protocol to the Cartagena Protocol on liability and redress indicates that an operator may mean any or all of the following: permit holder, developer, producer, notifier, exporter, importer, carrier, or supplier. The implementation should be by the domestic law. Review of liability and redress clauses among these countries shows that the difference is only on who would be responsible for damage or harm resulting from the use of modified living organisms. Countries that have commercialized GMO use, or that have started confined field trials (CFT) have placed the users of GMOs as liable for any damage that may arise from the use of GMOs. On the other hand, the liability and redress clauses for countries that have not started confined field trials is placed to persons who imports, users, or/and developers of the technology.

The review highlights that whenever the liability is beyond the user of the technologies, there is hesitation by developers to invest or release the technology. Since the Cartagena Protocol highlights that the liability for damage caused by the use of GMOs may be placed to permit holder, developer, producer, notifier, exporter, importer, carrier, or supplier is an indication that the regulation on liability and redress is not segregative. Therefore, as countries develop their regulatory frameworks, they should not be segregative, but should be neutral.

As countries develop the regulations on the liability and redress should be in line with what is defined in the Cartagena Protocol.
5. CONCLUSION

Agricultural production is a dynamic process whose efficiency and profitability depend on the deployment and employment of appropriate technologies. Therefore, farmers are likely to adopt a technology if the net benefits are more than the cost of production. The purpose of the study was to: (i) assess the profitability of Bt cotton production if Zambian cotton farmers adopted the technology; (ii) ascertain the yield from conventional cotton production required for Zambian cotton farmers to double or triple the net benefits of Bt cotton production; and (iii) review the perceptions about Bt cotton/GMO among cotton stakeholders in Zambia. The study highlights the following findings:

a) Farmers can realize a net positive benefit if they adopted Bt cotton under 28% yield advantage and 46% insecticide cost reduction advantage conditions. The additional net benefit from Bt cotton adoption will be around US$60 per hectare. The category of farmers to gain the highest additional net benefit (US$81) per hectare is one that cultivates less than 0.5 hectares. The main reason for higher positive net benefits is a yield (production per unit area) which is relatively huge with smaller fields. However, the average national additional net benefit of US$60 per hectare is unlikely to attractive farmers to adopt a new technology.

b) If farmers doubled or tripled the net benefits after adopting Bt cotton, the yields from conventional cotton production systems that can warrant that increase are; 1,220 kg/ha and 1,650 kg/ha respectively—28% and 10% of Zambian cotton-producing households can achieve these yields. On the other hand, the majority of the cotton households produce 864 kg of seed cotton/ha.

c) Despite the positive additional net benefits can get after adopting Bt cotton, an introduction of the technology has not been done in Zambia. Review of literature and discussion with the main stakeholders pointed out to some challenges that have hindered this:

   i. Divergence views among stakeholders especially proponents of GMOs and those against the technology. That creates confusion among the policy makers and the general public.

   ii. Zambian biosafety regulation especially the issue of liability and redress has been considered punitive by some stakeholder and they feel it may be a hindrance for the introduction of the technology in Zambia. Review and comparison of biosafety regulations of some African countries that have introduced GMOs and those that have not shed some light. The liability for the damages to human health, animals, environment, and biodiversity caused by the introduction of GMOs is placed on the users of the technology and not the developers in those countries that have introduced GMOs in their countries. While the countries that have not introduced GMOs, the liability to the damage is placed on users, developers, importers, exporters, or producers.

   iii. The government has made some strides in providing an enabling environment for introduction of any GMO by formulating the policy, regulations and also the formation of National Biosafety Authority (NBA). Though some stakeholders feel, there was a lack of political will in the introduction of Bt cotton in Zambia.

   iv. Lessons learned from countries that have introduced GMOs in their countries show that building trust among stakeholders is cardinal in presenting the technology. Trust is developed through continuous dialogue and collaboration among stakeholders on issues of GMOs. Developed trust results in partners becoming more open.
6. RECOMMENDATIONS

The base yield is key in ensuring higher additional net benefits if farmers adopted Bt cotton. The base yield is not just affected by insect pest attack but by not implementing properly other agronomic factors such as land preparation, planting, plant population and weeding among others. Using the base yield of 864 kg/ha and 28% yield advantage and 46% insecticide, cost reduction resulted in additional net benefits of US$60. The additional net benefits (US$60) looks relatively small and cannot be attractive to farmers. To double or triple the net benefits, the yields need to increase by 97% and 165% respectively. Therefore, stakeholders need first to work on ways of improving the base yield if indeed farmers can realize double or triple net benefits. Furthermore, Zambia cannot shy away from the technology. The best it can do is to adopt the Bt cotton technology step by step approach through having confined field trials to assess its performance with a view to making informed decisions. The country can restrict the introduction of GMO crops to Bt cotton as it is a nonfood crop.

The understanding of Bt cotton technology is weak in Zambia. One major observation established during the study was the fact that cotton industry stakeholders had no common position regarding the need for Bt cotton in Zambia. There is a need for Cotton Development Trust, as an institution that may likely lead research efforts on Bt cotton, to carry out thorough consultations with industry players as it formulates its research priorities and objectives. The process will ensure that activities aimed at addressing felt needs as espoused by ultimate beneficiaries. A controversial technology such as Bt cotton would require that the cotton industry in Zambia speak with one united voice when demanding the introduction of the technology.

Additionally, given the high levels of misconceptions about genetic modification of crops, there is need to establish an open forum for agricultural biotechnology in Zambia with the objective of sharing information among Zambia’s agricultural stakeholders. Such a forum would be organized along similar principles and objectives as the Open Forum for Agricultural Biotechnology in Africa (OFAB).

Considering that the liability and redress clauses (compensation in case of damages as a result of using biotechnology clauses) of the Cartagena Protocol were completed in 2010 while the Zambian Biosafety Act was enacted in 2007, there is need to review and align it with the Cartagena Protocol which is the guiding principle for biosafety regulations.
# APPENDIX 1: LIST OF STAKEHOLDERS INTERVIEWED

<table>
<thead>
<tr>
<th>Nu</th>
<th>Name</th>
<th>Institution</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr. Fred Chambanege</td>
<td>Green Living Movement</td>
<td>+260979784927</td>
</tr>
<tr>
<td>2</td>
<td>Mr. Faustin Vuningoma</td>
<td>Pelum Association</td>
<td>+260966221739</td>
</tr>
<tr>
<td>3</td>
<td>Mr. Doris Musonda</td>
<td>National Biosafety Authority</td>
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REFERENCES


