



## **Padenga Crocodile Farming Operations**

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**DNSC 6254 Risk Management**

**Fall 2018**

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## 1. Project background

Southern Africa is the market leader when it comes to crocodile farming, exporting over 250,000 skins per year. Zimbabwe, Zambia, and South Africa hold the largest operations, with over \$30M worth of skins being exported from Zimbabwe alone.

The crocodile farming business is very lucrative, and caters to a specialized segment of the population, mainly the global luxury market. The skins are processed to make high-end handbags, shoes, jackets and other accessories while the meat is offered as an exotic delicacy at many fine dining restaurants.

Padenga Holdings Limited (PHL) is a public company listed on the Zimbabwe stock exchange as of Nov 2010. Its core business is the production and sale of crocodile and alligator skins and meat. Padenga exports 100% of the crocodile skins and runs 3 of the 6 approved crocodile farm operations in Zimbabwe. PHL also has an 80% ownership stake in Tallow Creek, an alligator ranch in Texas, USA. Holding 45% of the global market share, it supplies high quality skins to luxury fashion brands. In addition, Padenga's export approved abattoir processes and treats crocodile meat for export to Europe and Asia. PHL breeds the Nile Crocodile, which is the second largest crocodile after the saltwater crocodile. Nile crocs are known to grow up to 20 feet and weight over 800 lbs. They are highly valued for their boneless underbelly and soft leather.

### 1.1 Project Objective

We will assess the risks that Padenga Holdings Limited (PHL) faces in its crocodile farm operations using the Analytical Hierarchy Process (AHP). First, we will identify the risks to see what events are likely to occur. Then we will measure how much risk each event assumes and then analyze the risks to determine the expected loss to Padenga's objectives. After which, we will determine what measures can be taken to mitigate these events. Lastly, we'll decide and make recommendations for which resources to allocate to reduce the risks.

To carry out the Analytical Hierarchy Process, we will use Expert Choice (Riskion) a decision-making software that enables us to evaluate multi conflicting criteria.

### 1.2 Analytical Hierarchy Process Overview

AHP is a multi-criteria decision method which does not depend on assumptions and uses eigenvector computation to determine likelihoods and priorities for the objectives as well as priorities of events with respect to the objectives. This is done by making verbal evaluations (judgements) using the fundamental AHP judgment scale. This scale uses integers ranging from 1-9 and their corresponding verbal equivalents.

These words are ordinal measures and are mathematically meaningless as they do not give us the magnitude or intensity between the measures. However, with AHP and the eigenvector computation which factors inconsistency of the judgements made by ensuring, with enough redundancy and variety, that ratio-scale measures (priorities) are produced. The ratios between the measures gives us mathematically meaningful numbers.















**Fundamental AHP Judgement Scale**

- 1 - Equal
- 2 - Equal to moderate
- 3 - Moderate
- 4 - Moderate to strong
- 5 - Strong
- 6 - Strong to very strong
- 7 - Very strong
- 8 - Very strong to extreme,
- 9 - Extreme

**2. Project Structure****2.1 Identifying Risk Events**

Risks or risk events are defined as losses that have a given likelihood of occurring and can negatively impact our objectives or goals. When identifying risks, we took care not to confuse them with issues. Risks are events that have not taken place. However, if they are not mitigated, minimized or eliminated they can become issues. Issues are events that have already occurred. When identifying events, it is important to consider what consequences might occur if the event takes place and what the causes of the event could be.

Using AHP we identified 16 risk events that can cause a loss to PHL's business objectives as indicated in Figure 1.

Unique ID		Events
[09]		Temperature Excursions in the pens
[14]		Stunted crocodile growth
[15]		Stock value depreciates
[12]		Loss or damage to property
[16]		Loss of licensing
[20]		Loss of customers
[13]		Loss of animals
[18]		Incompliance - Farm audited/Inspected
[11]		Food (Protein) shortage
[08]		Fines imposed on the farm
[07]		Farm operations shutdown
[19]		Disease outbreak (Crocodiles)
[03]		Decrease in sales
[05]		Crocodiles put down
[01]		Crocodile meat contaminated
[10]		Aggravated/stressed crocodiles

*Figure 1: Risk Events*

## 2.2 Identifying Causes

Causes are factors that can lead to a risk event or events. They can also be classified as sources, hazards, threats, capabilities or intents. The causes were arranged into a hierarchy of causes. The purpose of using a hierarchy is to aid our brains in making better comparisons. When too many items are listed in a linear fashion, this limits our brains, and we are unable to make judgements well or comprehend the magnitude of those judgements. As shown in Figure 2, we identified 6 types of causes and their subtypes. These subtypes were arranged in homogeneous clusters. Classifying causes into a hierarchy makes it easier to compare the given causes to each other and gives us better measurements of our judgements.

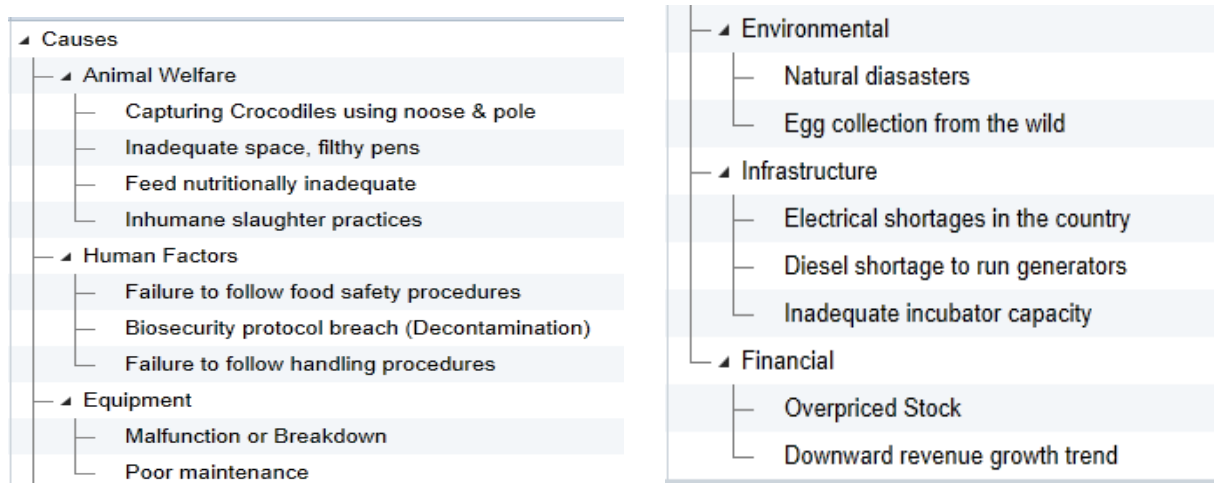


Figure 2: Causes

## 2.3 Identifying Objectives

Objectives are goals that are important to the organization. The same hierarchy concept is used in Figure 3 to structure the objectives and the sub-objectives with the consequences or impact the events would have on the objectives. The consequences or impacts are listed as losses that can happen to one or more assets. Figure 3 shows the 7 objectives we identified that events contribute to.

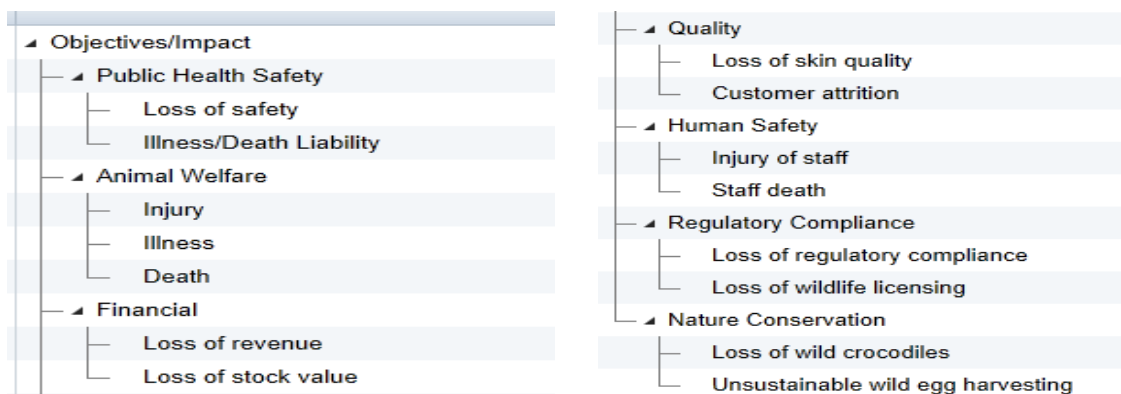


Figure 3: Objectives/Impacts

## 2.4 Participants and Roles

Figure 4 shows the participants roles, title, email addresses and if they participated in making judgements or evaluations. Depending on the roles, each participant may have had little, great or no participation in making judgements. This is solely determined by their job title and influence in the decision-making process.

<input type="checkbox"/>	Email Address	Participant Name	Permission	Has Data?
<input type="checkbox"/>	C.Watson@PHL.com	Charles Watson, Operations Mgr.	Evaluator	Yes
<input type="checkbox"/>	forman@gwu.edu	Professor Forman	Project Manager	No
<input type="checkbox"/>	G.Johnson@PHL.com	Gary Johnson, Chief Executive Officer (CEO)	Evaluator	Yes
<input type="checkbox"/>	J.Brown@PHL.com	Jimmy Brown, GM Kariba Crocodile Farm	Evaluator	Yes
<input type="checkbox"/>	Incube@gwu.edu	Lindile Ncube (Project Manager, PHL)	Project Manager	Yes
<input type="checkbox"/>	N.Welsh@PHL.com	Nigel Welsh, Abattoir (slaughter house) Mgr.	Evaluator	Yes
<input type="checkbox"/>	nstavrakakis@gwu.edu	Nicholas Stavrakakis	Project Manager	No
<input type="checkbox"/>	P.French@PHL.com	Pierre French, GM Ume Crocodile Farm	Evaluator	Yes
<input type="checkbox"/>	P.Moyo@PHL.com	Prince Moyo, GM Nyanyana Crocodile Farm	Evaluator	Yes
<input type="checkbox"/>	T.Jura@PHL.com	Tendai Jura, Chief Financial Officer (CFO)	Evaluator	Yes
<input type="checkbox"/>	tbrewton2020@gwu.edu	Tamara Brewton (Project Manager,PHL)	Project Manager	Yes

Figure 4: Participants and Roles

Based on their roles, each participant will make judgements or rather evaluations for specific causes and events that they have been allocated. Figure 5 is a sample showing the causes that Gary Johnson the CEO is responsible for making judgements. In this example he is responsible for making judgements on Animal welfare, Environmental and Financial causes. Each participant was also assigned roles for making judgements on objectives and events.

Participants

Groups

Participant Name
<input type="checkbox"/> Charles Watson, Operations Mgr.
<input type="checkbox"/> Professor Forman
<input checked="" type="checkbox"/> Gary Johnson, Chief Executive Officer (CEO)
<input type="checkbox"/> Jimmy Brown, GM Kariba Crocodile Farm
<input type="checkbox"/> Lindile Ncube (Project Manager, PHL)
<input type="checkbox"/> Nigel Welsh, Abattoir (slaughter house) Mgr.
<input type="checkbox"/> Nicholas Stavrakakis
<input type="checkbox"/> Pierre French, GM Ume Crocodile Farm
<input type="checkbox"/> Prince Moyo, GM Nyanyana Crocodile Farm
<input type="checkbox"/> Tendai Jura, Chief Financial Officer (CFO)
<input type="checkbox"/> Tamara Brewton (Project Manager,PHL)

Causes

Animal Welfare

Capturing Crocodiles using noose & pole  
Inadequate space, filthy pens  
Feed nutritionally inadequate  
Inhumane slaughter practices

Human Factors

Failure to follow food safety procedures  
Biosecurity protocol breach (Decontamination)  
Failure to follow handling procedures

Equipment

Equipment malfunction or Breakdown  
Equipment maintenance

Environmental

Natural diasasters  
Egg collection from the wild

Infrastructure

Electrical shortages in the country  
Diesel shortage to run generators  
Lack of incubator capacity

Financial

Overpriced Stock  
Downward revenue growth trend



*Figure 5: Sample of Participants Roles for Causes*

Figure 6 is a sample showing the events that participant Gary Johnson is responsible for making judgements on.

Participants		Groups		Events	No specific Sources	Sources																
Participant Name						Animal Welfare				Human Factors			Equipment		Environmental		Infrastructure		Financial			
						Capturing Crocod	Inadequate space	Feed nutritionally	Inhumane slaughter	Failure to follow h	Biosecurity protoc	Failure to follow h	Equipment malfun	Equipment maint	Natural disaster	Egg collection fra	Electrical shortage	Diesel shortage to	Lack of incubator	Overpriced Stock	Downward trend	
<input type="checkbox"/>	Charles Watson, Op	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Loss of animals																	
<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Loss of licensing																	
<input checked="" type="checkbox"/>	Gary Johnson, Chief	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Fines imposed on the fan																	
<input type="checkbox"/>	Jimmy Brown, GM Ki	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Food (Protein) shortage																	
<input type="checkbox"/>	Lindile Ncube (Proj	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Stunted crocodile growth																	
<input type="checkbox"/>	Nigel Welsh, Abattoir	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Temperature Excursions																	
<input type="checkbox"/>	Nicholas Stavrakakis	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Loss or damage to prope																	
<input type="checkbox"/>	Pierre French, GM Uk	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Stock value depreciates																	
<input type="checkbox"/>	Prince Moyo, GM Ny	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Crocodiles put down																	
<input type="checkbox"/>	Tendal Jura, Chief Fil	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Decrease in sales																	
<input type="checkbox"/>	Tamara Brewton (Pro	<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Aggravated/stressed cro																	
<input type="checkbox"/>		<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Crocodile meat contamin																	
<input type="checkbox"/>		<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Farm operations shutdown																	
<input type="checkbox"/>		<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Disease outbreak (Croco																	
<input type="checkbox"/>		<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Farm audited/inspected																	
<input type="checkbox"/>		<input type="checkbox"/>	Professor Forman	<input type="checkbox"/>	Loss of customers																	

*Figure 6: Sample of Participants Roles for Events*

### 3. Events and Source Mapping

#### 3.1 Likelihood of Events

Here we linked the causes we identified to events. Using a Vulnerabilities Grid in Figure 7. We identified what causes contributed to what events. It is normal for sources to only contribute to some events so there can be sources with no event contributions.

Events	Sources														
	Animal Welfare					Human Factors			Equipment		Environmental		Infrastructure		Financial
	Capturing Crocod	Inadequate space	Feed nutritionally	Inhumane slaughter	Failure to follow fd	Biosecurity protog	Failure to follow fd	Malfunction of Bre	Poor maintenance	Natural disasters	Egg collection fail	Electrical shortage	Diesel shortage	Inadequate incub	Overpriced Stock
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Temperature Excursions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Stunted crocodile growth	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Stock value depreciates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Loss or damage to prope	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Loss of licensing	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Loss of customers	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Loss of animals	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Incompliance - Farm aud	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Food (Protein) shortage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Fines imposed on the fan	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Farm operations shutdown	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Disease outbreak (Croco	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Decrease in sales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Crocodiles put down	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Crocodile meat contamin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Aggravated/stressed croc	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 7: Vulnerabilities Grid

### 3.2 Impact of Events

Here we linked events to the objectives. We identified the events that contributed to the objectives and the impacts they posed to those objectives using a Consequences Grid in Figure 8.

Events	Objectives/Consequences													
	Public Health Safety		Animal Welfare			Financial		Quality		Human Safety		Regulatory Compliance		Nature Conservation
	Loss of safety	Death Liability	Injury	Illness	Death	Loss of revenue	Loss of stock value	Loss of skin quality	Customer attrition	Injury of staff	Staff death	Loss of regulatory	Loss of wildlife lic	Loss of wild crocod
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Loss of animals	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Loss of licensing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Fines imposed on the fan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Food (Protein) shortage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Stunted crocodile growth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Temperature Excursions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Loss or damage to prope	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Stock value depreciates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Crocodiles put down	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Decrease in sales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Aggravated/stressed croc	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Crocodile meat contamin	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Farm operations shutdown	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Disease outbreak (Croco	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Farm audited/inspected	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Loss of customers	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Figure 8: Consequences Grid

## 4. Risk Measurements Methods/Scales

Measurements (judgements) in Expert choice (Riskion) can be **absolute**, representing the likelihood of the source or event occurring. They can also be **relative**, representing the likelihood compared to the



likelihood of other sources or events. Various measurement methods can be used in Expert choice (Riskion) to obtain ratio-scale priorities.

**Pairwise Comparisons** - Paired comparisons are made by determining the priority between two elements and then determining how much more of a priority that element is over the other

**Pairwise with given likelihood** - a source is selected known or assumed Likelihood specified.

**Pairwise probabilities** - range of values for probabilities ranging from 0 to 100%

**Direct measurement** - using known likelihood

**Step function** - contains verbal intensities and likelihoods and translates data into likelihoods

**Utility curve** - translates data into likelihoods

**Rating scale** - specifies Intensities (words) and corresponding likelihoods

#### 4.1 Measurement Methods for sources – Likelihood of Events

Figure 9 shows 3 different rating scales we used. To rate animal welfare, equipment, environmental, and infrastructure we used the 'wide likelihood rating scale' to measure the possibility or likelihood of the events occurring.

Measure Likelihood	Measurement Type	Measurement Scale or Given Likelihood	Action
Causes	Rating Scale	WIDE LIKELIHOOD RATING SCALE	Copy Edit
Animal Welfare	Rating Scale	WIDE LIKELIHOOD RATING SCALE	Copy Edit
Capturing Crocodiles using noose & pole			
Inadequate space, filthy pens			
Feed nutritionally inadequate			
Inhumane slaughter practices			
Human Factors	Rating Scale	Human Factors Scale	Copy Edit
Failure to follow food safety procedures			
Biosecurity protocol breach (Decontamin			
Failure to follow handling procedures			
Equipment	Rating Scale	WIDE LIKELIHOOD RATING SCALE	Copy Edit
Equipment malfunction or Breakdown			
Equipment maintenance			
Environmental	Rating Scale	WIDE LIKELIHOOD RATING SCALE	Copy Edit
Natural disasters			
Egg collection from the wild			
Infrastructure	Rating Scale	WIDE LIKELIHOOD RATING SCALE	Copy Edit
Electrical shortages in the country			
Diesel shortage to run generators			
Lack of incubator capacity			
Financial	Rating Scale	HIGH LIKELIHOOD RATING SCALE	Copy Edit
Overpriced Stock			
Downward revenue growth trend			

Figure 9: Methods for sources – Likelihood of Events

We used the Human Factors Rating Scale Figure 10, to determine the likelihood of: Failure to follow food safety procedures, Biosecurity protocol breach, and Failure to follow handling procedures shown in Figure 9 above.

Scale name:	Human Factors Scale	
Description:		
Intensity Name	Likelihood	Description
Extremely low	0.0200	
Very Low	0.0500	
Low	0.1000	
Medium Low	0.1500	
Medium	0.2500	
High	0.3000	
Very High	0.3500	
Extremely High	0.4000	

Figure 10: Human Factors Rating scale

## 4.2 Measurement Methods for Events– Likelihood of Events

In Figure 11 the 'Wide likelihood' and 'Human factors' rating scales were used to measure the likelihood of the events listed.

Measure Event Likelihoods	Measurement Type Default: Rating Scale	Measurement Scale or Given Likelihood	Action
▲ Causes			
▲ Animal Welfare			
Capturing Crocodiles using noose & pole	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Inadequate space, filthy pens	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Feed nutritionally inadequate	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Inhumane slaughter practices	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
▲ Human Factors			
Failure to follow food safety procedures	Rating Scale ▼	Human Factors Scale ▼	Copy Edit
Biosecurity protocol breach (Decontamin	Rating Scale ▼	Human Factors Scale ▼	Copy Edit
Failure to follow handling procedures	Rating Scale ▼	Human Factors Scale ▼	Copy Edit
▲ Equipment			
Equipment malfunction or Breakdown	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Equipment maintenance	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
▲ Environmental			
Natural diasasters	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Egg collection from the wild	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
▲ Infrastructure			
Electrical shortages in the country	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Diesel shortage to run generators	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
Lack of incubator capacity	Rating Scale ▼	WIDE LIKELIHOOD RATING SCALE ▼	Copy Edit
▲ Financial			
Overpriced Stock	Rating Scale ▼	HIGH LIKELIHOOD RATING SCALE ▼	Copy Edit
Downward revenue growth trend	Rating Scale ▼	HIGH LIKELIHOOD RATING SCALE ▼	Copy Edit

Figure 11: Methods for Events– Likelihood of Events

We used the 'Wide and High' Likelihood rating scale to measure the likelihood of the events for: Animal Welfare, Equipment, Environmental, Infrastructure, and Financial. Figure 12

Scale name:	WIDE LIKELIHOOD RATING SCALE	
Description:		
Intensity Name	Likelihood	Description
Almost Certain	0.9900	Almost certain to occur
Highly Likely	0.9500	Highly likely to occur
Very likely	0.9000	Very likely to occur
More than likely	0.8000	More than likely to occur
Likely	0.6667	Likely to occur
fifty fifty	0.5000	fifty fifty to occur
One in 3	0.3333	One in 3 to occur
One in 4	0.2500	One in 4 to occur
One in 5	0.2000	One in 5 to occur

*Figure 12: Wide Likelihood Rating Scale*

Figure 13 shows the 'High Likelihood Rating Scale' and the difference in ratings of how likely or unlikely events would occur.

Scale name:	HIGH LIKELIHOOD RATING SCALE	
Description:		
Intensity Name	Likelihood	Description
Almost Certain	0.9900	Almost certain to occur
Highly Likely	0.9500	Highly likely to occur
Very likely	0.9000	Very likely to occur
More than likely	0.8000	More than likely to occur
Likely	0.6667	Likely to occur
fifty fifty	0.5000	fifty fifty to occur
One in 4	0.2500	One in 4 to occur
Somewhat Unlikely (One in 10)	0.1000	Somewhat Unlikely (One in 10) to occur
Unlikely (One in 20)	0.0500	Unlikely (One in 20) to occur

*Figure 13: High Likelihood Rating Scale*

### 4.3 Measurement Methods for Objectives – Impact of Events

In Figure 14 we used Pairwise Comparisons to measure the importance of the events with respect to the objectives.

Measure Importance With Respect To	Measurement Type	Measurement Scale	Action
▾ Objectives/Impact	Pairwise Comparisons		Copy
▾ Public Health Safety	Pairwise Comparisons		Copy
Loss of safety			
Death Liability			
▾ Animal Welfare	Pairwise Comparisons		Copy
Injury			
Illness			
Death			
▾ Financial	Pairwise Comparisons		Copy
Loss of revenue			
Loss of stock value			
▾ Quality	Pairwise Comparisons		Copy
Loss of skin quality			
Customer attrition			
▾ Human Safety	Pairwise Comparisons		Copy
Injury of staff			
Staff death			
▾ Regulatory Compliance	Pairwise Comparisons		Copy
Loss of regulatory compliance			
Loss of wildlife licensing			
▾ Nature Conservation	Pairwise Comparisons		Copy
Loss of wild crocodiles			
Unsustainable wild egg harvesting			

Figure 14: Methods for Objectives – Impact of Events

#### 4.4 Measurement Methods for Events – Impact of Events

We used the ‘Default Impact Scale’ to measure: Public Health Safety, Animal Welfare, Financial, Quality, Human Safety, Regulatory Compliance, and Nature Conservation in Figure 15. Figure 16 shows how the rating scale was distributed.

Measure Events With Respect To	Measurement Type Default: Rating Scale	Measurement Scale	Action
▾ Objectives/Impact			
▾ Public Health Safety			
Loss of safety	Rating Scale	Default Impact Scale	Copy Edit
Death Liability	Rating Scale	Default Impact Scale	Copy Edit
▾ Animal Welfare			
Injury	Rating Scale	Default Impact Scale	Copy Edit
Illness	Rating Scale	Default Impact Scale	Copy Edit
Death	Rating Scale	Default Impact Scale	Copy Edit
▾ Financial			
Loss of revenue	Rating Scale	Default Impact Scale	Copy Edit
Loss of stock value	Rating Scale	Default Impact Scale	Copy Edit
▾ Quality			
Loss of skin quality	Rating Scale	Default Impact Scale	Copy Edit
Customer attrition	Rating Scale	Default Impact Scale	Copy Edit
▾ Human Safety			
Injury of staff	Rating Scale	Default Impact Scale	Copy Edit
Staff death	Rating Scale	Default Impact Scale	Copy Edit
▾ Regulatory Compliance			
Loss of regulatory compliance	Rating Scale	Default Impact Scale	Copy Edit
Loss of wildlife licensing	Rating Scale	Default Impact Scale	Copy Edit
▾ Nature Conservation			
Loss of wild crocodiles	Rating Scale	Default Impact Scale	Copy Edit
Unsustainable wild egg harvesting	Rating Scale	Default Impact Scale	Copy Edit

Figure 15: Methods for Events – Impact of Events

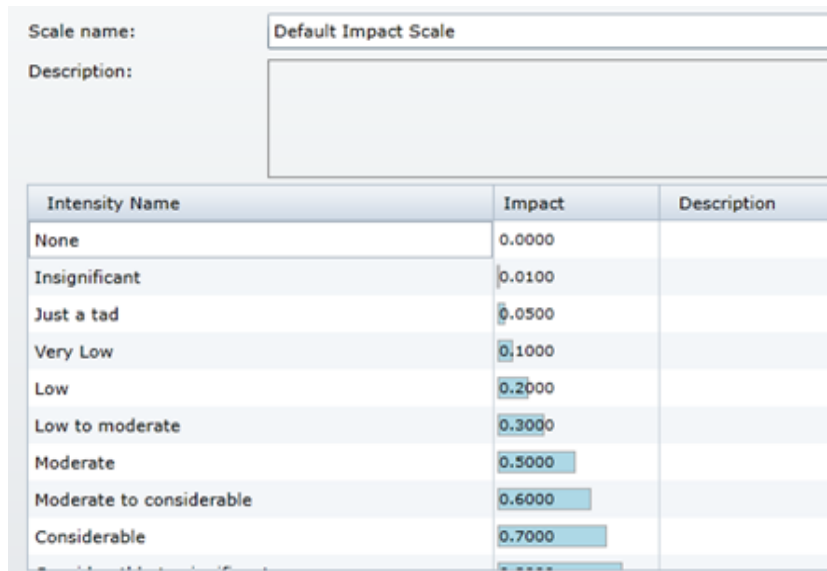


Figure 16: Default Impact scale

## 5.0 Synthesis/Sensitivity Analysis

After making judgements Expert Choice combines the measurements also known as synthesis to show the priorities of the causes, events and the impacts using several tools. The tools can help organizations examine the results and test out different scenarios of how those results could play out. If the results do not look right or maybe some things that needed to be factored in where left out the team can address these questions that arise. We must remember that AHP is a process not a series of steps to follow to completion. It is an ongoing process that can be repeated until the results obtained are in line with the intuition of those making the judgements.

### 5.1 Synthesis: Likelihood of Events and Sources

Figure 17 shows the likelihoods of events. The likelihoods are not mutually exclusive and therefore some will add up to greater than 100% such in Figure 17 where the likelihood “stock value depreciates” adds up to 124.04%. If the likelihoods were mutually exclusive the pairwise and normalizations would add up to 100%. However, these are computed values which result from multiplying the computed likelihood of causes by the computed likelihood of the event given the cause. We normalize the results by doing simulations which remove the errors caused by double counting.

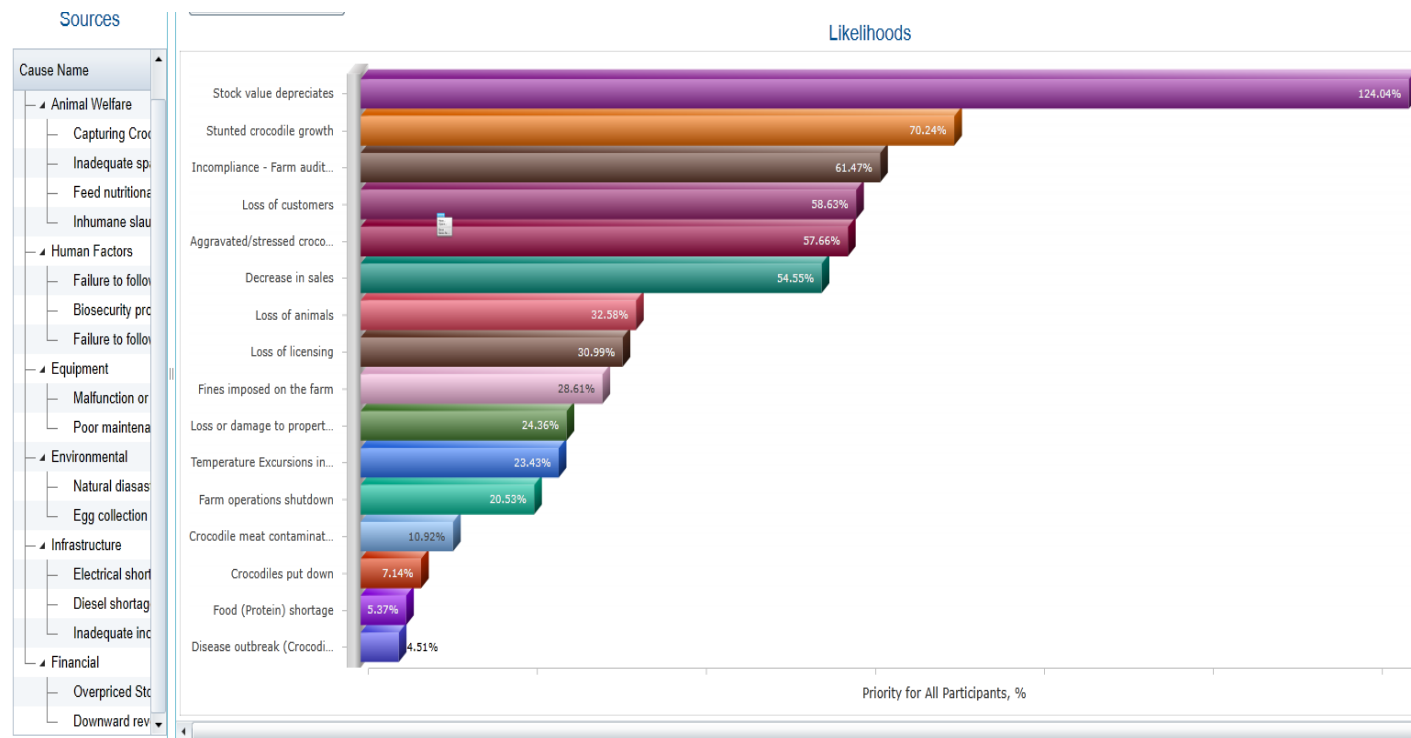


Figure 17: Likelihoods of Events

Figure 18 shows the likelihood of causes. Financial causes have a 83.52% likelihood, animal Welfare has a 69.26% likelihood and Environmental causes have a 55.55% likelihood. Infrastructure causes have the least likelihood of 17.78%

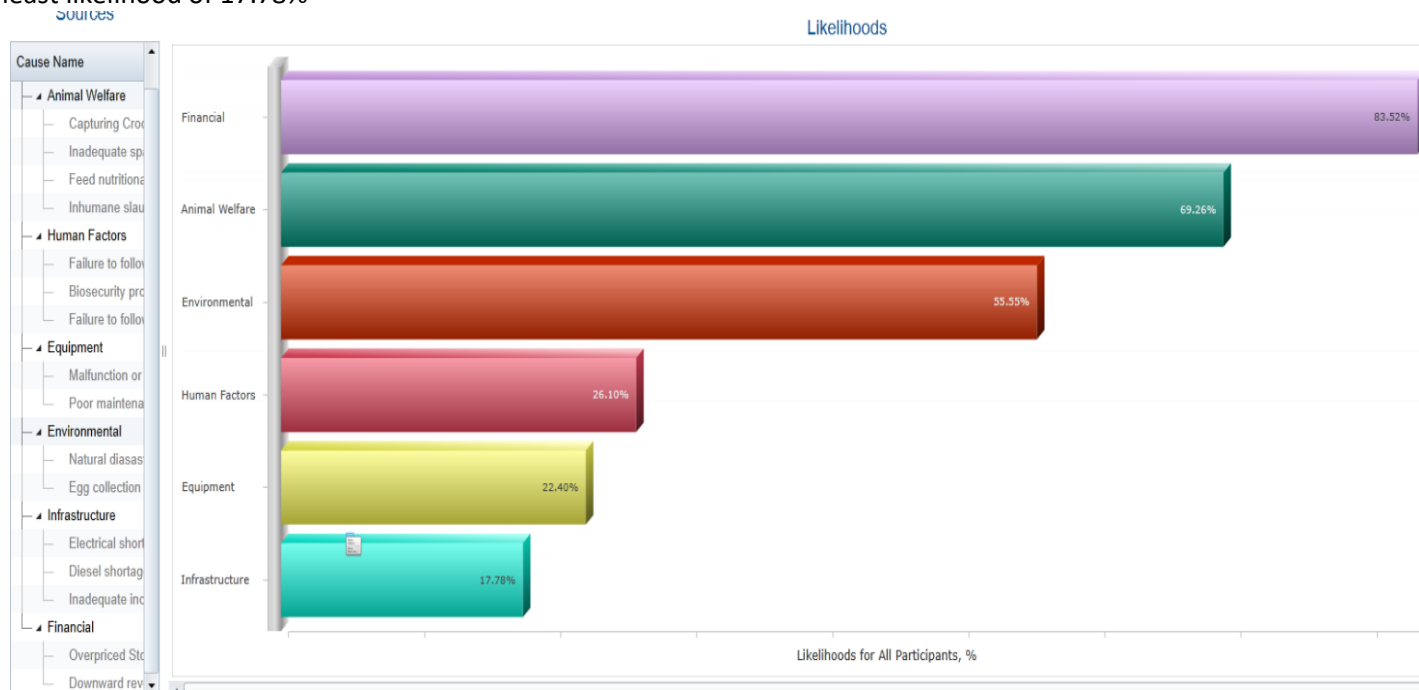


Figure 18: Likelihood of Causes



## 5.2 Synthesis: Impact of Events and Objectives

The impact of events on the objectives is shown in Figure 19. The greatest impact to PHL's objectives is Disease outbreak, Decrease in sales and loss of customers with 58.62%, 52.80% and 48.55% impact respectively.

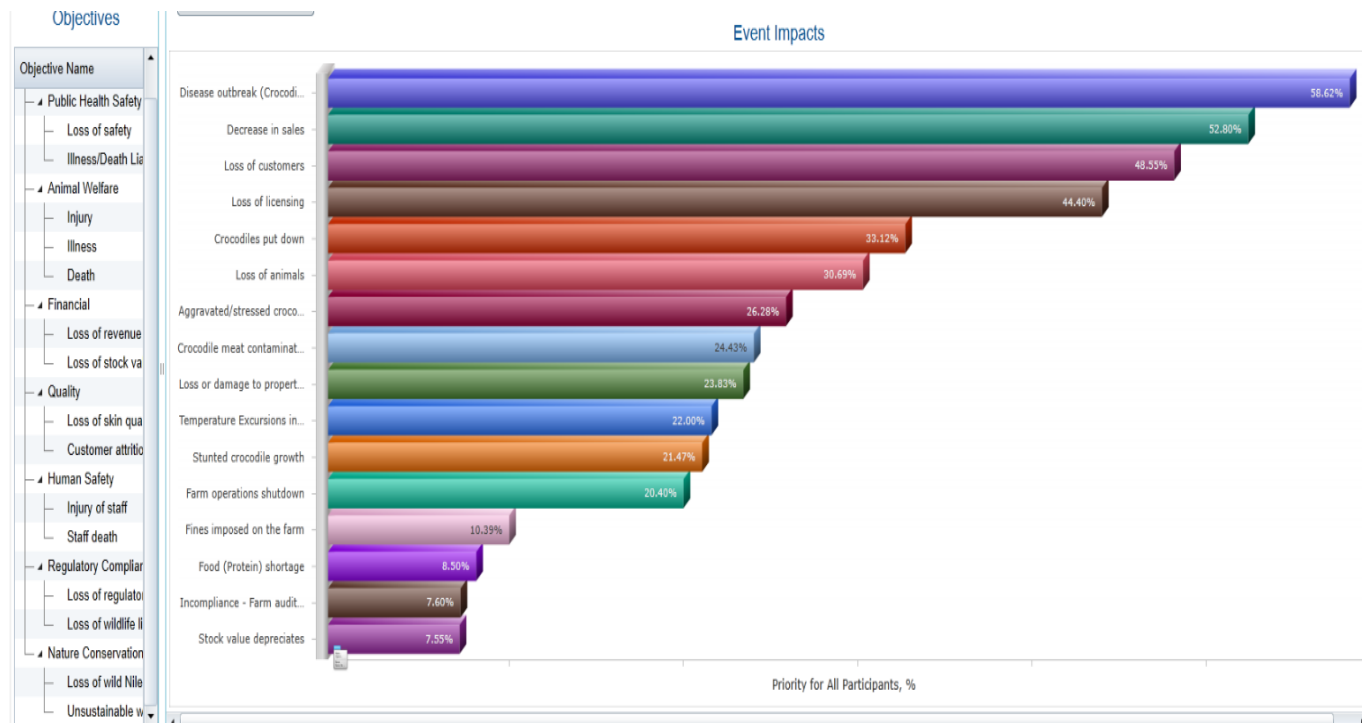


Figure 19: Impact of Events on Objectives

Figure 20 shows the priority of objectives. The most important objective to PHL is Financial with a priority of 46.30% followed by Quality with a priority of 25.27%. The least priority objective is Nature Conservation with a priority of 1.68%.

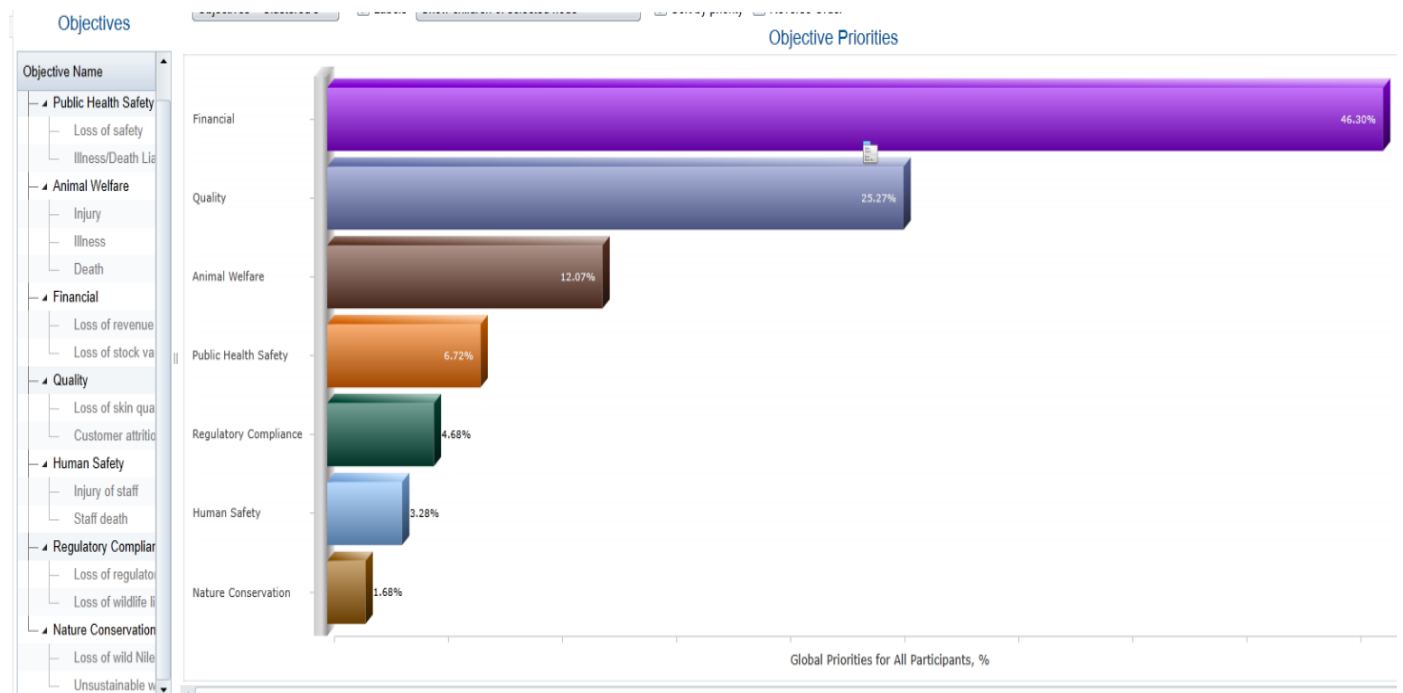


Figure 20: Priorities of Objectives

The event impacts depend upon how important PHL thinks the objectives are. The Dynamic sensitivity of objectives in Figure 21 can be used to evaluate the impacts of the events on objectives. This can be done by adjusting the bars on one objective, and the corresponding objectives and impacts will adjust simultaneously making this a powerful tool to use.

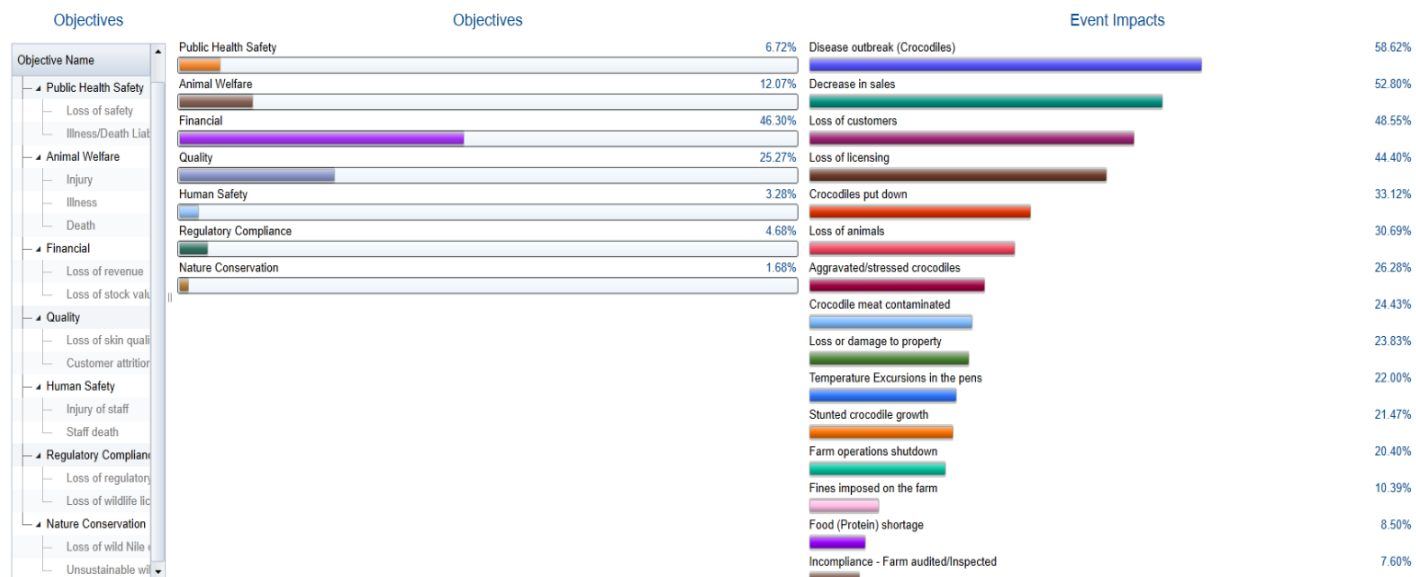


Figure 21: Dynamic Sensitivity of Objectives

Similar to the Dynamic sensitivity tool, Figure 22 shows the Performance sensitivity of objectives. In this tool the consequences of each event are measured against each of the objectives. The results show sensitivity to changes of the objectives. When an objective is adjusted, the corresponding objectives and consequences adjust simultaneously.

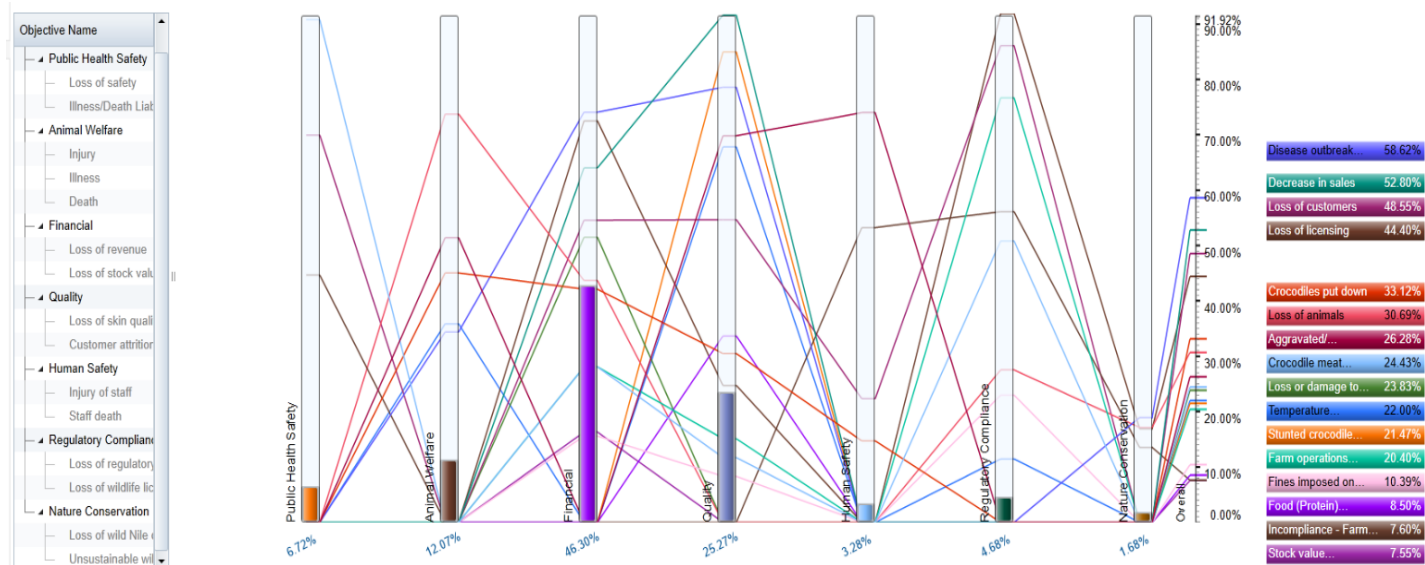


Figure 22: Performance Sensitivity of Objectives

## 6. Risk Review

Risk is the product of event likelihoods and their impact. The following figures show the review of the risk results without controls and risk results with controls.

### 6.1 Overall Risk (without Controls)

Figure 23 and 24 respectively, show the computed results with a total risk of 152% which corresponds to a financial risk of \$492,428,143M. Computed results are based on all the judgements and relationships that we identified, and these results are not as accurate. This is because several events can cause loss to the same objective, and the computed results gives us averages resulting in some events being counted more than once as contributing to the same objective. This results in inflated risk results. We perform simulations to eliminate this double counting giving us more accurate results. The simulated results show a total risk of 69% corresponding to a financial risk of about \$222M. The events posing the largest risk of 13% are Decrease in sales and Loss of customers. A monetary value of the entire enterprise was entered to show a value of \$324,960,000M and all the other monetary values of specific events are computed in proportion to their priorities.

## Brewton &amp; Ncube

Figure 23: Overall Likelihoods, Impacts, Computed and Simulated Risks

Figure 24: Overall Likelihoods, Impacts, Computed and Simulated Risk monetary values

18

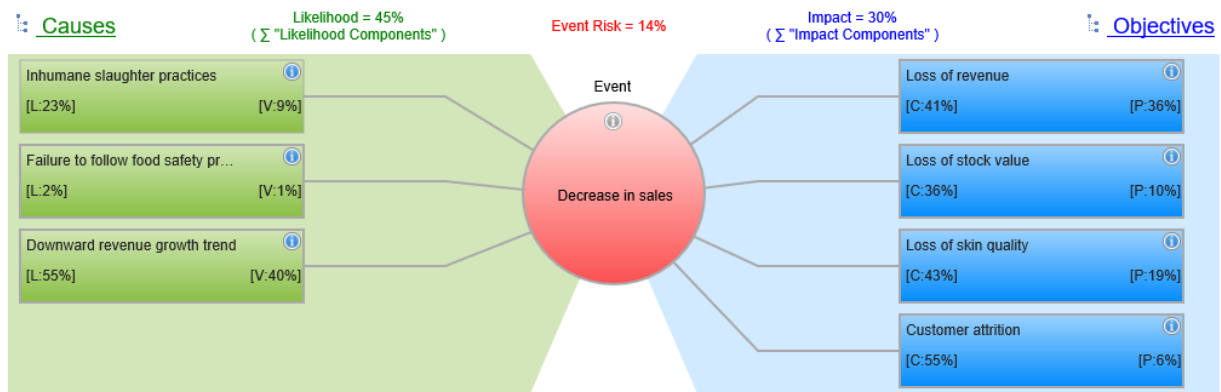


Figure 25: Bow-Tie Event Risk for Decrease in Sales

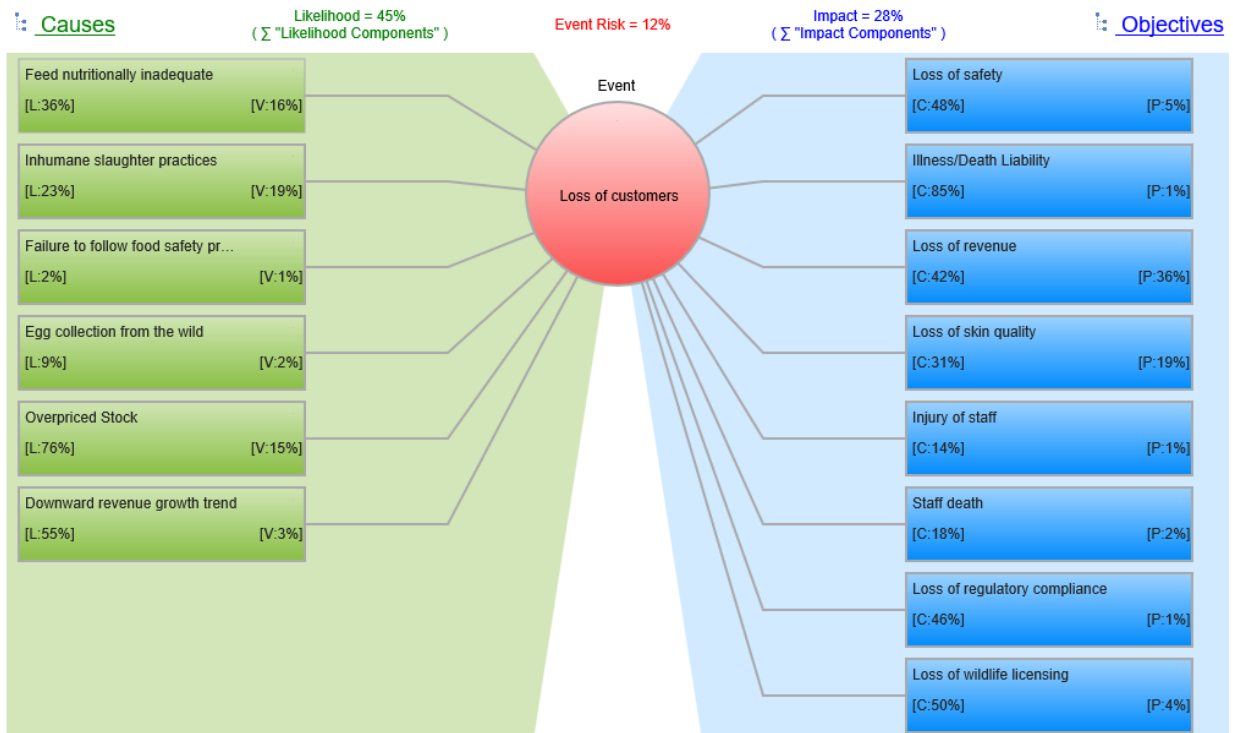


Figure 26: Bow-Tie Event Risk for Loss of customers

The loss exceedance curve shows the average loss and it also helps in deciding how much loss an organization is willing to take. Figure 27 shows the Loss exceedance curve with an average loss of 69% which matches our expected loss of the simulated results generated in Figure 23: Overall Likelihoods, Impacts, and Risks corresponding to \$222M. There is also a 5% VAR (Value at Risk) that the loss will exceed 92.69% of PHL's value which corresponds to 5% probability of losing \$301M.

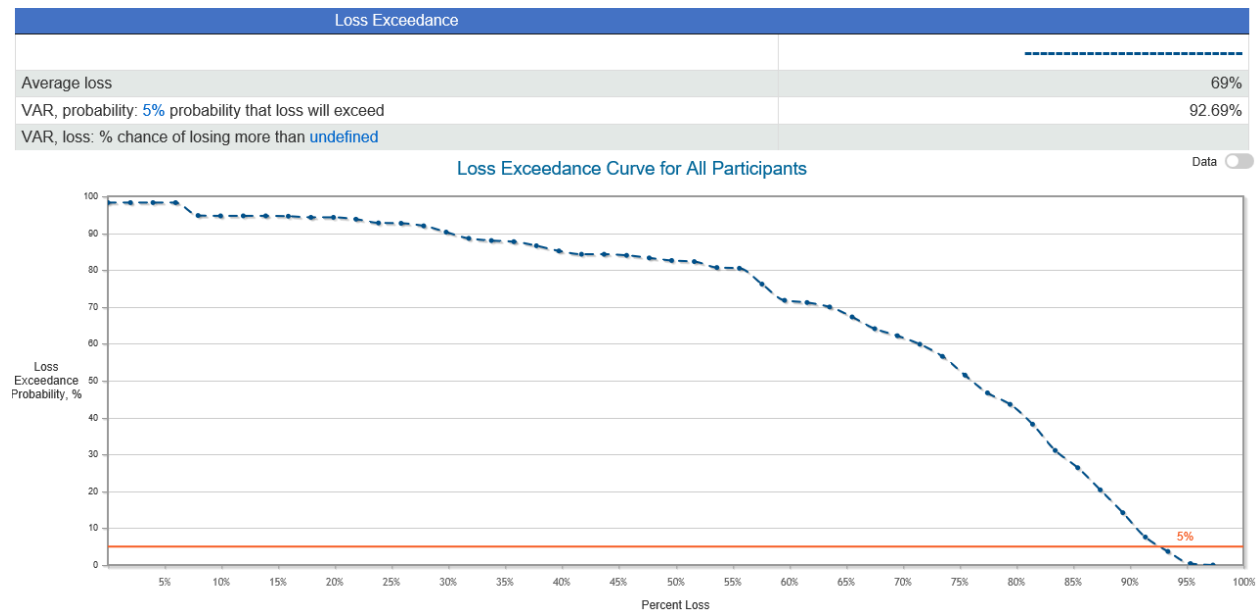


Figure 27: Loss exceedance curve without controls

Figure 28 shows the first trial from the Monte Carlo simulations that Riskion performs. It lists the causes and the computed probability or likelihood of those causes. Random numbers are generated and if the random number is less than the computed probability value then the cause took place. For example, Cause [6], capturing crocodiles using a noose and pole has a 28.8% chance of taking place. The cause did not happen since the random number is greater than the probability value. On the right, all the events given the cause are listed. Some events do not have any causes. There are four events, stunted crocodile growth, loss of animals, Incompliance, and Aggravated/stressed crocodiles that have a likelihood of occurring given Cause [7]. Since Cause [7] has a random number less than the probability we can say that in this trial the cause fired or happened. Figure 28 shows that 7 causes fired contributing to 9 event occurrences resulting in a total loss of \$306.94M. The computer simulates thousands of these trials and computes the probability of loss based on the number of trials performed.



## Loss Exceedance Curve for All Participants

Step: [Back to Chart](#)Causes (without controls)  
Number of causes that fired: 7Total loss of simulation: \$306.94M  
Number of Events that fired: 9

Cause Name	Cause Random()	Probability	Event Name	Random()	Vulnerability	Impact	Risk
[6] Capturing Crocodiles using noose & pole	0.87077936	0.28852201	Temperature Excursions in the pens [No Causes]				
[7] Inadequate space, filthy pens	0.21402658	0.36274022	Stunted crocodile growth $C_{10}=[7]$	0.22343538	0.83333749	\$22.82M	\$6.90M
[18] Feed nutritionally inadequate	0.29073208	0.37929362	Stock value depreciates $C_{10}=[32]$	0.70181532	0.83333331	\$24.53M	\$12.90M
[34] Inhumane slaughter practices	0.04152417	0.25547457	Loss or damage to property $C_{10}=[12]$	0.24321974	0.70833749	\$20.37M	\$4.96M
[9] Failure to follow food safety procedures	0.91312585	0.023925	Loss of licensing $C_{10}=[34]$	0.22917634	0.69167501	\$44.10M	\$7.79M
[10] Biosecurity protocol breach (Decontamination)	0.00688383	0.080475	Loss of customers $C_{10}=[18]$	0.46020124	0.47905001	\$52.75M	\$9.58M
[11] Failure to follow handling procedures	0.67356221	0.09352501	Loss of animals $C_{10}=[7]$	0.07030691	0.354	\$36.27M	\$4.66M
[16] Malfunction or Breakdown	0.90370424	0.07649601	Incompliance - Farm audited/Inspected $C_{10}=[7]$	0.29927501	0.58331251	\$13.97M	\$2.96M
[17] Poor maintenance	0.87592567	0.102648	Food (Protein) shortage [No Causes]				
[12] Natural disasters	0.31150521	0.34389418	Fines imposed on the farm [No Causes]				
[24] Egg collection from the wild	0.15607094	0.11110001	Farm operations shutdown [No Causes]				
[14] Electrical shortages in the country	0.38307268	0.09876741	Disease outbreak (Crocodiles) $C_{10}=[10]$	0.28038768	0.37857142	\$58.62M	\$1.79M
[15] Diesel shortage to run generators	0.9942492	0.04097778	Decrease in sales [No Causes]				
[28] Inadequate incubator capacity	0.01945566	0.10864593	Crocodiles put down [No Causes]				
[30] Overpriced Stock	0.77444246	0.76558977	Crocodile meat contaminated [No Causes]				
[32] Downward revenue growth trend	0.14909258	0.63104087	Aggravated/stressed crocodiles $C_{10}=[7]$	0.75842901	0.79167497	\$33.51M	\$9.62M

Figure 28: Loss exceedance curve without controls

## 6.2 Risk Map (without Controls)

Figure 29 shows a risk or heat map with risk regions corresponding to the percent likelihood of the risk vs the Impact in dollars without controls. Risk events that contribute less than 2% risk are in the green region. Risk events that contribute between 2 - 5% are located in the yellow region. While events contributing over 5% risk are in the red regions that is set based on how much risk PHL is willing to have. The two highest risk events “Decrease in sales” and “Loss of customers” are in the red region, meaning they contribute to over 5% risk. These events are also represented in the bow-tie diagrams shown in Figure 25 and 26 above.

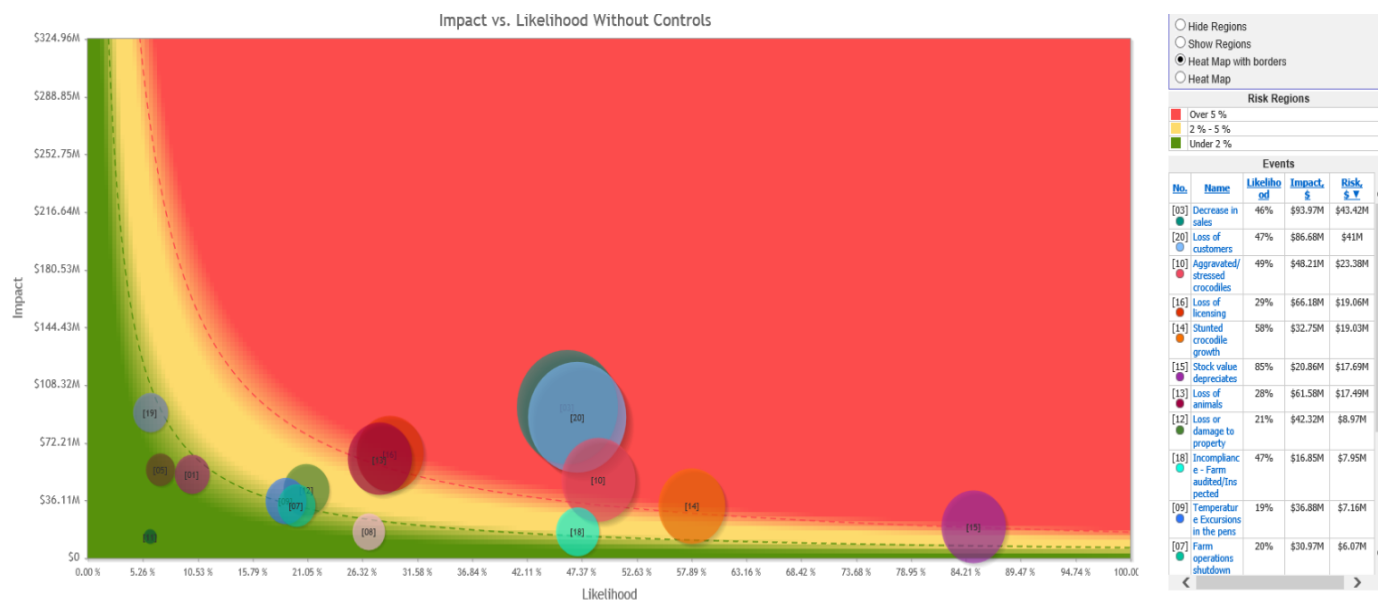


Figure 29: Risk Map without Controls

### 6.3 Identifying and selecting controls

We introduced controls to reduce our average risk and tolerance for risk as shown in the loss exceedance curve in Figure 27. There are three types of controls that we can use. They are, controls for the causes, events given causes and controls we can put on the consequence of the events to the objectives. Figure 30 shows the 20 controls we identified. Four controls for the causes, five controls for the events given the cause and the rest of the controls were applied to the consequences of the events to the objectives. We also listed a cost associated with the controls along with the number of applications the control had. For example, control “Construction of 80 new pens” has 12 applications as shown in Figure 31.

Index	Control Name	Control for	Selected	Cost	Applications	Categories	Must	Must Not
01	<input type="checkbox"/> Scheduled Maintenance Visits	Cause	Yes	75000	2		<input type="checkbox"/>	<input type="checkbox"/>
02	<input type="checkbox"/> Annual Mandatory training for crocodile handlers	Cause	Yes	15000	7		<input type="checkbox"/>	<input type="checkbox"/>
03	<input type="checkbox"/> Commission a solar power plant	Cause	Yes	275000	2		<input type="checkbox"/>	<input type="checkbox"/>
04	<input type="checkbox"/> Financial consulting services	Cause	Yes	25000	2		<input type="checkbox"/>	<input type="checkbox"/>
05	<input type="checkbox"/> Working Capital Management	Vulnerability	Yes	275000	4		<input type="checkbox"/>	<input type="checkbox"/>
06	<input type="checkbox"/> Expand meat export market	Vulnerability	Yes	31500	2		<input type="checkbox"/>	<input type="checkbox"/>
07	<input type="checkbox"/> Scheduled Vet Inspections at different growth milestones	Vulnerability	Yes	35000	3		<input type="checkbox"/>	<input type="checkbox"/>
08	<input type="checkbox"/> Enclosure inspections to ensure appropriate stocking densities	Vulnerability	Yes	12000	3		<input type="checkbox"/>	<input type="checkbox"/>
09	<input type="checkbox"/> Public Relations Specialist Services	Vulnerability	Yes	10000	7		<input type="checkbox"/>	<input type="checkbox"/>
10	<input type="checkbox"/> Utilize Crocprofit Forecasting Tool	Consequence	Yes	3500	2		<input type="checkbox"/>	<input type="checkbox"/>
11	<input type="checkbox"/> Construction 80 new pens	Consequence	Yes	75000	12		<input type="checkbox"/>	<input type="checkbox"/>
12	<input type="checkbox"/> Harvest younger crocodile stock	Consequence	Yes	100000	1		<input type="checkbox"/>	<input type="checkbox"/>
13	<input type="checkbox"/> Water Quality Checks & Regulation Systems	Consequence	Yes	20000	2		<input type="checkbox"/>	<input type="checkbox"/>
14	<input type="checkbox"/> Effluent disposal systems	Consequence	Yes	90000	2		<input type="checkbox"/>	<input type="checkbox"/>
15	<input type="checkbox"/> Ozone treatment	Consequence	Yes	5000	2		<input type="checkbox"/>	<input type="checkbox"/>
16	<input type="checkbox"/> Maintain Licensing and Permits	Consequence	Yes	5500	5		<input type="checkbox"/>	<input type="checkbox"/>
17	<input type="checkbox"/> QA checks for meat contamination	Consequence	Yes	10000	8		<input type="checkbox"/>	<input type="checkbox"/>
18	<input type="checkbox"/> Quarterly Safety & Occupational health training	Consequence	Yes	12000	3		<input type="checkbox"/>	<input type="checkbox"/>
19	<input type="checkbox"/> Performance Indicators/records	Consequence	Yes	20000	1		<input type="checkbox"/>	<input type="checkbox"/>
20	<input type="checkbox"/> Quarterly Internal Financial Audits	Consequence	Yes	70000	3		<input type="checkbox"/>	<input type="checkbox"/>

Figure 30: Selecting Controls

"Construction 80 new pens" is applied to:			
Objective Name	Event Name	Measure Type	Effectiveness
Loss of skin quality	Stunted crocodile growth	Direct	0.8700
Loss of wildlife licensing	Loss of licensing	Direct	0.7600
Injury	Loss of animals	Direct	0.8700
Illness	Loss of animals	Direct	0.8900
Illness	Disease outbreak (Crocodiles)	Direct	0.8700
Death	Disease outbreak (Crocodiles)	Direct	0.8800
Loss of skin quality	Decrease in sales	Direct	0.8700
Loss of skin quality	Aggravated/stressed crocodiles	Direct	0.8700
Injury	Aggravated/stressed crocodiles	Direct	0.9400
Death	Aggravated/stressed crocodiles	Direct	0.8700
Injury of staff	Aggravated/stressed crocodiles	Direct	0.7800
Staff death	Aggravated/stressed crocodiles	Direct	0.7600

Figure 31: Applications for control "Construction of 80 new pens"

Figure 32 shows a sample of the controls mapped for causes. We mapped all the controls to their corresponding causes, vulnerabilities and consequences. The control "Annual mandatory training for crocodile handlers" impacts causes such as Animal Welfare and Human Factors.

Controls for Cause Likelihoods											
Control Name	Causes										
	Animal Welfare				Human Factors			Equipment		Environmental	
	<input type="checkbox"/> Capturing Crocodiles using noose & pole	<input type="checkbox"/> Inadequate space, filthy pens	<input type="checkbox"/> Feed nutritionally inadequate	<input type="checkbox"/> Inhumane slaughter practices	<input type="checkbox"/> Failure to follow food safety procedures	<input type="checkbox"/> Biosecurity protocol breach (Decontamination)	<input type="checkbox"/> Failure to follow handling procedures	<input type="checkbox"/> Malfunction or Breakdown	<input type="checkbox"/> Poor maintenance	<input type="checkbox"/> Natural disasters	<input type="checkbox"/> Egg collection from the wild
<input type="checkbox"/> 1. Scheduled Maintenance Visits To calibrate and run QC checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> 2. Annual Mandatory training for crocodile handlers For crocodile handlers to reinforce best practices	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 32: Mapping controls

After mapping the controls, the participants measured the controls by assigning a number between 0 and 1 which corresponds to the percent effectiveness of that control. Figure 33 shows the measurement of 0.78 for control “Annual mandatory training for crocodile handlers” and Figure 34 shows its effectiveness of 78%. All controls were measured to see how effective they were on their corresponding causes, vulnerabilities and consequences.

**02. Annual Mandatory training for crocodile handlers**

Please enter a value between 0 and 1:

0.78

[Comment](#)

02. Annual Mandatory training for crocodile...

**Annual Mandatory training for crocodile handlers**

For crocodile handlers to reinforce best practices

Figure 33: Control measurement

Effectiveness of Cause Controls							
Control Name	Animal Welfare				Human Factors		
	Capturing Crocodiles using noose & pole	Inadequate space, filthy pens	Feed nutritionally inadequate	Inhumane slaughter practices	Failure to follow food safety procedures	Biosecurity protocol breach (Decontamination)	Failure to follow handling procedures
1. Scheduled Maintenance Visits To calibrate and run QC checks							
2. Annual Mandatory training for crocodile handlers For crocodile handlers to reinforce best practices	0.7	0.86	0.6	0.78	0.34	0.9	0.88

Figure 34: Effectiveness of controls

## 6.4 Overall Risk (with Controls)

After applying controls, we looked at how effective the controls were at reducing the likelihood, impact and overall risks that were shown earlier in Figures 23 and 24. Figure 35 shows the new results with a risk reduction of 52% corresponding to almost \$170M after applying all 20 controls.

No.	Event	Likelihood Simulated	All Participants Impact Simulated	Risk Simulated ▼
[12]	Loss or damage to property	18%	19%	3%
[20]	Loss of customers	10%	28%	3%
[13]	Loss of animals	15%	18%	3%
[16]	Loss of licensing	8%	30%	2%
[05]	Crocodiles put down	5%	25%	1%
[01]	Crocodile meat contaminated	5%	16%	1%
[07]	Farm operations shutdown	3%	10%	0.3%
[10]	Aggravated/stressed crocodiles	10%	4%	0.4%
[11]	Food (Protein) shortage	5%	8%	0.4%
[19]	Disease outbreak (Crocodiles)	2%	29%	0.5%
[08]	Fines imposed on the farm	5%	6%	0.3%
[14]	Stunted crocodile growth	5%	6%	0.3%
[09]	Temperature Excursions in the pens	6%	5%	0.3%
[03]	Decrease in sales	2%	6%	0.1%
[18]	Incompliance - Farm audited/Inspected	6%	2%	0.1%
[15]	Stock value depreciates	16%	0.3%	0.05%
				Simulated
# Controls		Cost of Controls		Total Risk
20		\$1,164,500		69%
		How Selected		Risk Reduction
		Manually selected		52%
				Residual Risk
				16%

Likelihood Simulated	All Participants Impact, \$ Simulated	Risk, \$ Simulated ▼
18%	61,890,713	10,954,656
10%	91,894,113	9,281,305
15%	59,131,868	8,869,780
8%	98,751,050	7,998,835
5%	81,182,643	4,221,497
5%	51,401,619	2,570,080
3%	31,590,764	1,074,086
10%	12,664,924	1,266,492
5%	27,191,147	1,305,175
2%	95,706,796	1,531,308
5%	19,543,361	996,711
5%	20,483,163	962,708
6%	17,755,234	1,136,335
2%	18,162,821	381,419
6%	5,932,650	338,161
16%	953,431	156,362
		Simulated
		Total Risk
		\$222,752,450
		Risk Reduction
		\$169,707,534
		Residual Risk
		\$53,044,915

Figure 35: Overall Likelihoods, Impacts, Simulated Risk and Monetary values

## 6.5 Risk Map (with Controls)

Figure 36 shows the risk map with all the controls applied. We can see that the controls were effective in reducing the risks. Decrease in sales and loss of customers had 14% and 12% expected risk and the controls brought the expected risk down to 0.1% and 3% decreasing the expected monetary risk from \$44M and \$40M down to roughly \$381,419.00 and \$9M. PHL is left with a residual risk of \$53M down from \$222M. Figure 36 shows that the controls were very effective in bringing the risk down by 52%

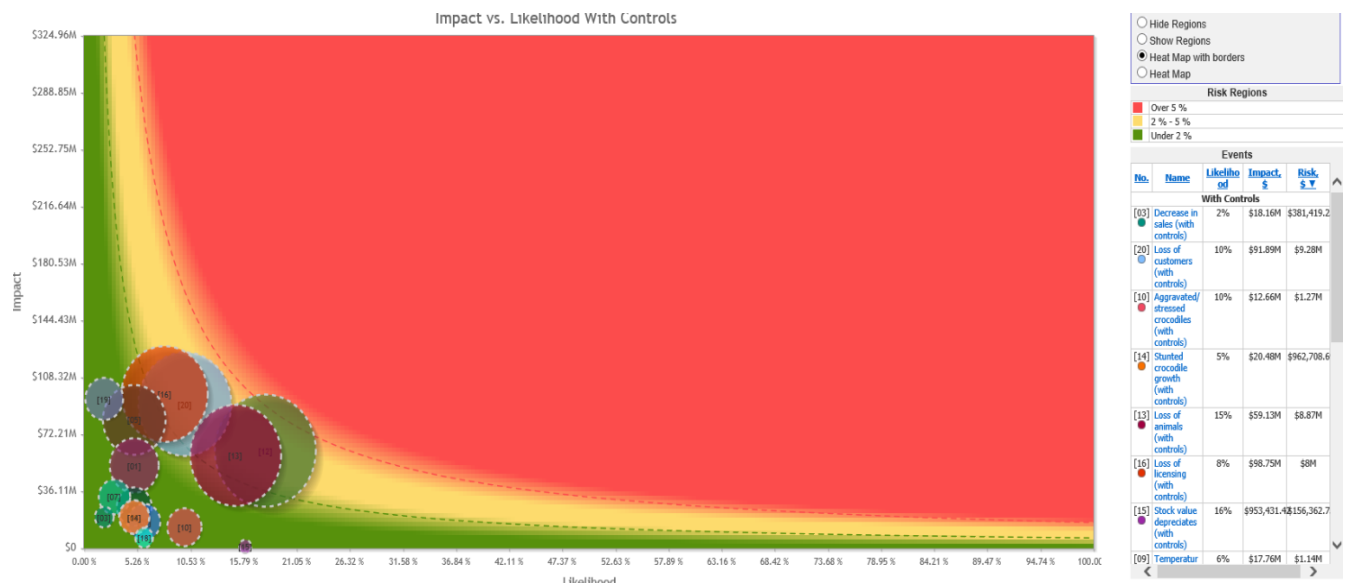


Figure 36: Risk Map with Controls

Figure 37 shows the loss exceedance curve with and without controls. There is a 53% reduction bringing the expected loss to 16%. There is a 5% value at risk that the loss will exceed 47.8% of PHL's value which is about \$155M with all the controls in place.

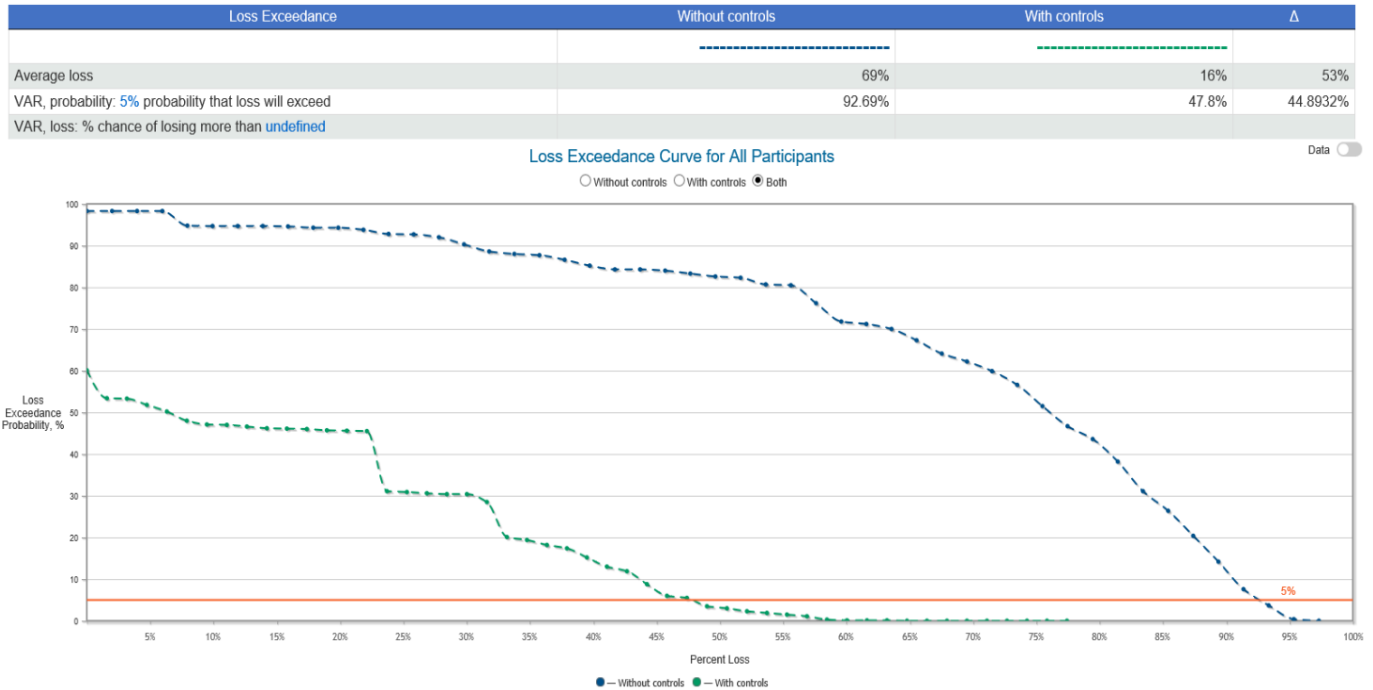


Figure 37: Loss exceedance curve with and without controls

## 6.6 Optimizing controls

Riskion enables us to optimize controls. We are able to select a budget that can be allocated to implementing controls and Riskion will select which controls to fund based on the inputted budget. In Figure 38, we selected a budget of \$750,000 to fund controls. With this budget we were able to select 16 out of 20 of our controls. This left \$418,500 of the controls unfunded and \$746,000 of the controls funded. We also selected controls that “must” be factored into the optimization. These controls were therefore included in the selected budget. Optimizing the controls as they are currently selected will allow the business to be profitable and run efficiently.



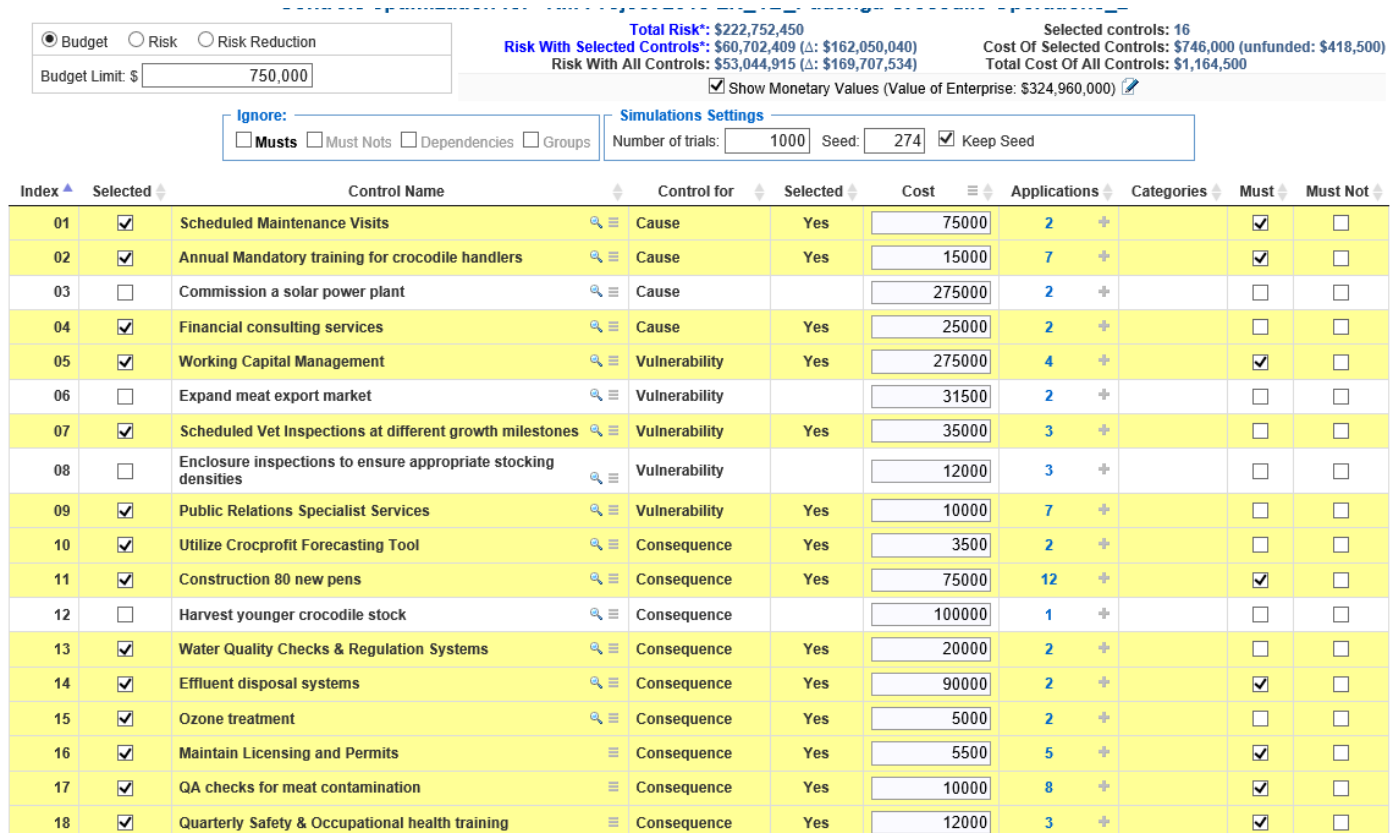


Figure 38: Optimizing Controls

Figure 39 show the Efficient Frontier with several budgets selected and the results from the optimization showing which controls are funded under that budget. We can see that with a control budget selection of \$698,700 the monetary risk to PHL would be roughly \$87M with a risk reduction of \$371M. The more money that is spent on controls the more risk can be reduced. There is a sharp difference in risk reduction as shown in Figure 40 when spending \$698,000 than when spending \$756,000. The risk with selected controls somewhat evens out between a budget of \$756,000 and \$873,000 before we see another sharp decline in the risk with selected controls at a budget of about \$1.16M.

Controls/Budget	\$698,700	\$756,925	\$815,150	\$873,375
Cost Of Controls	\$697,500	\$754,500	\$811,000	\$858,000
Expected Savings, \$	\$370.96M	\$381.17M	\$383.04M	\$385.68M
Investment Leverage	532.84	506.2	473.31	450.51
Risk Reduction, \$	\$371.65M	\$381.93M	\$383.85M	\$386.54M
Risk with Selected Controls, \$	\$87.90M	\$77.63M	\$75.72M	\$73.02M
Funded controls	1. Scheduled Maintenance Visits 2. Annual Mandatory training for crocodile handlers 5. Working Capital Management 11. Construction 80 new pens 13. Water Quality Checks & Regulation Systems 14. Effluent disposal systems 15. Ozone treatment 16. Maintain Licensing and Permits 17. QA checks for meat contamination 18. Quarterly Safety & Occupational health training 19. Performance indicators/records 4. Financial consulting services 20. Quarterly Internal Financial Audits	1. Scheduled Maintenance Visits 2. Annual Mandatory training for crocodile handlers 5. Working Capital Management 7. Scheduled Vet Inspections at different growth milestones 8. Enclosure inspections to ensure appropriate stocking densities 11. Construction 80 new pens 13. Water Quality Checks & Regulation Systems 14. Effluent disposal systems 15. Ozone treatment 16. Maintain Licensing and Permits 17. QA checks for meat contamination 18. Quarterly Safety & Occupational health training 19. Performance indicators/records 4. Financial consulting services 9. Public Relations Specialist Services 20. Quarterly Internal Financial Audits	1. Scheduled Maintenance Visits 2. Annual Mandatory training for crocodile handlers 5. Working Capital Management 10. Utilize Crocprofit Forecasting Tool 11. Construction 80 new pens 12. Harvest younger crocodile stock 13. Water Quality Checks & Regulation Systems 14. Effluent disposal systems 15. Ozone treatment 16. Maintain Licensing and Permits 17. QA checks for meat contamination 18. Quarterly Safety & Occupational health training 19. Performance indicators/records 4. Financial consulting services 9. Public Relations Specialist Services 20. Quarterly Internal Financial Audits	1. Scheduled Maintenance Visits 2. Annual Mandatory training for crocodile handlers 5. Working Capital Management 7. Scheduled Vet Inspections at different growth milestones 8. Enclosure inspections to ensure appropriate stocking densities 10. Utilize Crocprofit Forecasting Tool 11. Construction 80 new pens 12. Harvest younger crocodile stock 13. Water Quality Checks & Regulation Systems 14. Effluent disposal systems 15. Ozone treatment 16. Maintain Licensing and Permits 17. QA checks for meat contamination 18. Quarterly Safety & Occupational health training 19. Performance indicators/records 4. Financial consulting services 9. Public Relations Specialist Services 20. Quarterly Internal Financial Audits

Figure 39: Efficient Frontier w/ budget selections

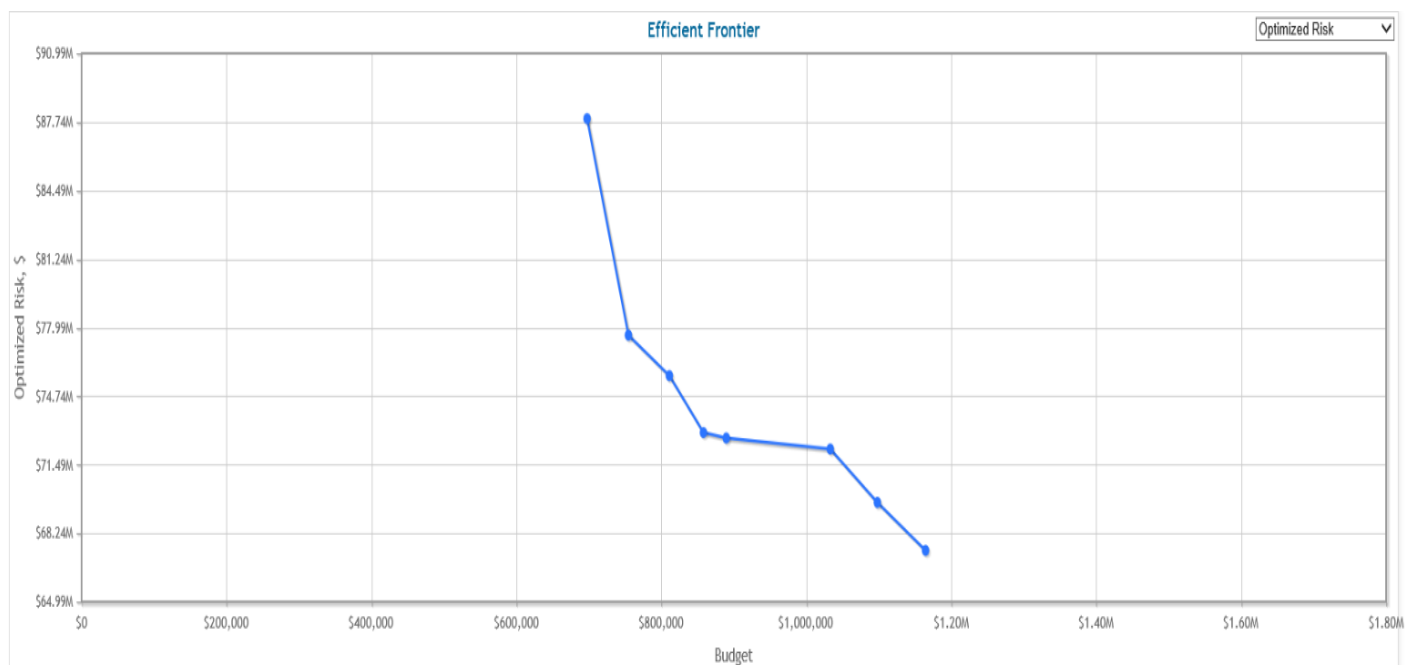


Figure 40: Efficient Frontier Optimized Risk

## 7. Recommendation and Conclusion

Currently there are over one million crocodile skins traded on the international market every year, exported legally from about 30 countries across the world. Padenga has been faced with and has overcome many challenges. The crocodile operation had the highest increase in sales recording a 3.6% increase compared to the massive 53% decrease in alligator skin sales in 2017 due to natural disasters. While this can be a very profitable business, it can take up to five years or more to setup a profitable farm. The owners must invest in special diets for the animals to succeed among other expenses.

We have learned through researching this project that crocodile products have a wide range of uses in different parts of the world. While the crocodiles are largely farmed for their skins and leather production, the main byproduct of crocodile farming is meat. Crocodile meat is considered 'exotic' and sold commercially to top end restaurants mostly in Europe and the Far East. So as the global economy grows, the demand for luxury products will likely continue to rise. This will continue to provide Padenga a unique business opportunity to produce and sell exotic crocodile skins and products.

We feel Padenga is will continue to see a successful return for its business. While a budget of \$750,000 has been selected to mitigate risk the optimization of controls at different budgets provides Padenga with some options to consider in regard to increasing the money budgeted to controls.

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