CHAPTER FOUR

RISK ANALYSIS AND EVALUATION

4.1 Concept of Risk Analysis and Evaluation

Risk analysis is the process of identifying, evaluating, and prioritizing potential risks or uncertainties that may impact the achievement of objectives, and then taking measures to mitigate or manage these risks. The primary goal of risk analysis is to make informed decisions by quantifying and understanding the potential impact and likelihood of various risks. This helps organizations or individuals prepare for and respond to unforeseen events.

Once risks have been identified, the risk manager must measure and evaluate them. This involves measuring potential losses and the probability that it is likely to occur. The analysis requires Risk analysis involves the assessment of the likelihood (probability) and impact (severity). There are numerous methods of measuring the likelihood and impact of risks ranging from qualitative to quantitative methods.

4.2 Need for Risk Analysis

Risk analysis plays a pivotal role across a multitude of domains, serving as a strategic tool to assess and manage the uncertainties that loom over decision-making processes.

1. **Quantifying Risk Magnitude:** Risk measurement allows for the quantification of the potential impact of identified risks. This numerical assessment provides a clear understanding of the magnitude of each risk, making it easier to compare and prioritize risks effectively.
2. **Risk Ranking and Prioritization:** Through risk evaluation, risks can be ranked based on their significance and potential consequences. This ranking aids in prioritizing risks, ensuring that resources and efforts are directed toward addressing the most critical ones first.
3. **Risk Tolerance Alignment:** Evaluating risks helps organizations align their risk tolerance levels with their risk management strategies. Understanding the acceptable level of risk assists in determining which risks should be actively managed or mitigated and which can be accepted or transferred.

4. **Informed Decision-Making:** By evaluating risks, decision-makers can make more informed choices about which risks require attention and resources. It enables them to weigh the potential benefits and costs of risk mitigation strategies.
5. **Resource Allocation:** Risk measurement and evaluation support efficient resource allocation by directing resources towards managing high-impact, high-probability risks, and minimizing the allocation to lower-priority risks.
6. **Risk Mitigation Planning:** A thorough evaluation of risks informs the development of risk mitigation plans. It guides the selection of appropriate risk mitigation strategies, such as avoidance, reduction, transfer, or acceptance.
7. **Compliance and Reporting:** In certain industries, regulatory compliance requires the quantification and reporting of risks. Risk measurement and evaluation help organizations fulfill these compliance requirements.

4.3 Risk Analysis Techniques

1. **The Prouty Approach**

This straightforward non-mathematical approach identifies four broad categories of loss likelihood

i) Almost nil - extremely unlikely

ii) Slight - has not happened, but could happen

iii) Moderate - happens once in a while

iv) Definite - happens regularly.

There are also three categories of loss impact:

i) *Slight* - the organization can readily retain each loss

ii) *Significant* - the organization cannot retain the whole of the loss, some part must be transferred

iii) *Severe* - virtually all of the loss must be transferred or the survival of the organization is endangered.

(i), (ii) and (iii) above vary with the size of the organization and its financial resources

Figure 3—Illustration of a Frequency and Loss Exposure Prouty Matrix

		Loss Frequency			
		Almost Nil	Slight	Moderate	Definite
Loss Severity	Severe	Transfer	Reduce or prevent	Reduce or prevent	Avoid
	Significant	Retain	Transfer	Reduce or prevent	Avoid
	Slight	Retain	Transfer	Prevent	Prevent

These broad categories can be readily understood, but the financial significance must be inferred, thus there is need for some kind of mathematical basis.

2. Risk Maps

Companies not only generate risk maps to capture impact and likelihood but also to demonstrate how risks look when put together in one place. The value of the map is that it reflects the collective wisdom of the parties involved. Furthermore, risk maps capture considerable risk information in one place that is easily reviewed. A basic risk map captures both impact and likelihood.

When assessing likelihood or probability, the following scales can be used:

a) Low, medium, or high;

b) Improbable, possible, probably, or near certainty; and

c) Slight, not likely, likely, highly likely, expected

The same is true for assessing impact:

a) Low, medium, or high impact;

b) Minor, moderate, critical, or survival; and

c) Money levels, such as Kshs. 1 million, Kshs. 5 million, etc.

When qualitatively assessing these risks, it is also possible to estimate ranges.

For example, a company might determine that there is a low probability of a customer-related risk

having an impact of Kshs.100 million, a moderate probability (or best guess) of a Kshs.50 million impact, and a high probability of a Kshs. 10 million impact.

Risk maps can help an organization determine how to respond to a risk. One weakness in risk maps (and in silo risk management) is that maps do not capture any risk correlations. Ignoring risk correlations can lead to ineffective and inefficient risk management. Risk correlations can be considered for financial risks or non-financial risks. For instance, how some companies manage one foreign currency exposure should be considered with how they manage another foreign currency exposure. Managing these in silos (without an enterprise-wide approach) can be inefficient because dollar exposures to not only the yen or euro ignore that the yen and euro are also correlated.

Similarly, silo risk management would ignore the fact that the movement of interest rates could influence an organization's pension obligations and debt obligations differently. Also how an organization manages commodity exposure today should be factored in with how it plans to change its long-term strategy to manage that same exposure. As is evident, correlations among risks and an enterprise-wide approach are critical.

3. Probability Theory

The probability of an event is measurement of the chance that the event will occur within a given time period. Probability can be expressed as a number that varies between 0 and 1.

0 = the event *cannot* occur

1 = the event is *certain* to occur

Values in between can be expressed as fractions (1/2; 1/100) decimals, (0.5; 0.01) or percentages (50%; 1%). The closer the probability to 1, (or 100%) the more likely the event becomes. There are two possible approaches to determining probability:

A Priori

A Posteriori

A Priori

This is based on *facts* which are evident at the *beginning.* There are a known number of outcomes.

Each outcome has a probability which is known, or can precisely be calculated.

Example 1

In the toss of a coin, the probability of this landing with the "head" up is ½ because: There are two equally possible outcomes - a head or a tail; *one* of these two represents the event being determined.

Example 2

In the same way, the probability of drawing an ace from a well-shuffled deck of cards is 1/13 because out of 52 cards there are four aces.

A Posteriori

Probabilities are based on past experience. (Posterior = back) This is sometimes known as the statistical probability, because the true probability is estimated from the observed number of exposures and previous occurrences.

Example 1

If a fast-food kiosk had 10,000 identical mandazi stalls throughout the country and 200 were damaged by fire in one year, they might assume that the probability of fire in one of their stands was 200/10 000 or 1/50.

Example 2

In a fleet of 100 similar vehicles, 25 are damaged in accidents. The probability is 1/4.

The Multiplication Rule (First Law of Probability

The first law of probability states:

a) The probability that two or more independent exposure units will suffer a loss is equal to the product of the probabilities of loss for each of these units.
b) More simply, this is called the *Multiplication Rule.*

Suppose that four shipments are made to the same four customers, ABC and D, every month.

From past statistics, the spatial interpretation shows the probability of theft of any one of the four shipments to be 1/4.

In our example, if the probability of each unit being involved is 1/4, then Two units 1/4 x 1/4 = 1/16

Three units 1/4 x 1/4 x 1/4 = 1/64 Four units 1/4 x 1/4 x 1/4 x 1/4 = 1/256

On this basis, it may be possible to negotiate a reasonable rate of premium,

Formula

Shortening Probability to 'P' and calling the units A, B, C and D, this could be written as: P (A and B) = P (A) x P (B)

P (A, B and C) = P (A) x P (B) x P(C), and so on.

Application

Now consider two buildings, A and B. A is a woodworking shop, with a probability of fire of 0.05. B is a metal workshop, where the probability is 0.02. The buildings are so close together that if one catches fire, there is an 85% chance (.85) that the other will burn as well.

P (A) = 0.05

P (B) = 0.02

P (A/B) or (B/A) = 0.85

P (A *and* B) = P (A) × P (B/A)

= (0.05) (0.85)

= 0.0425 or about 1/24

Notice that this is the probability if building a starts the fire and spreads it to building B - probability (A and B). There is a lesser probability that B is first to catch fire (B and A)

P (B and A) = P (B) × P (A/B)

= (0.02) (0.85)

= 0.017 Or nearly 1/60.

Additions Rule

In the above examples, there are *two* probabilities - the event will, or will *not* occur. Because the scenario represents certainty, the sum or total of *all* the alternatives must equal one.If the probability of a car accident is 1/4, the probability of *no* accident is 3/4. If the probability of a building having a fire is 0.05, the probability of it not having one is 0.95.

Probability Trees

We can use this fact in drawing up a probability tree, which is a useful way of illustrating how events combine.

4. Event Tree Analysis (ETA)

ETA is based on a binary logic in which an event either has or has not happened or a component

has or has not failed. It is valuable in analyzing the consequences arising from a failure or undesired event. An event tree begins with an initiating event such as a component failure, increase in temperature/pressure or a release of a hazardous substance. The consequences of the event are followed through a series of possible paths. Each path is assigned a probability of occurrence and the probability of various outcomes can be calculated.

ETA is a useful tool for major accident hazard assessment. In major accidents ETA is used for the evaluation of possible consequences following a release of toxic/flammable vapors cloud from a process and to analyze the impact on plant, personnel, general public and the environment.

5. Gain/Loss Curves

Every item written into a firm's profit and loss account and its balance sheet is a stochastic variable with a probability distribution derived from probability distributions for each factor of production. Using this approach, we are able to derive a probability distribution for any measure used in valuing companies and in evaluating strategic investment decisions. Indeed, using this evaluation approach it is possible to calculate expected gain, loss and their probability.

Company X has generated the following probabilities for annual loss as a result of post-harvestdeterioration risk.

Annual loss amount (in Millions of Ksh)	0.3	0.48	0.68	1.13	1.15	1.50	1.98	2.73	4.28
Probability that loss will not exceed amount	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1

Gain/loss curves are useful tools because they help an organization see how a risk can influence its financial statements and result in a gain or a loss. They also reveal the distribution of potential gains and losses. Gain/loss curves do not show correlations between risks, however, and they do not show all the risks in one place.

The curve shows how much money the company loses or gains from post-harvest deterioration risk. The horizontal axis represents dollars, and the vertical axis represents probability. The curve

shows that the organization loses Ksh 1.15 million dollars on average (at 50% probability in this illustration) as a result of this risk. Moving along the probability scale shows that, 90% of the time, this organization loses Ksh 300,000 because of this risk. The organization believes it loses Ksh 4.28 million about 10% of the time.

The shape of the probability curve provides concise information concerning risk. The lower the risk the steeper the probability curve, whereas the flatter the curve the higher the risk is evident. Knowing how big of an impact a risk causes over a distribution of probabilities provides management with the information necessary to decide how much money to spend managing the risk. Gain/loss curves can also reveal that some risks occasionally generate gains instead of losses. Developing gain/loss curves require substantial data collection, and a company has to balance the data collection efforts with the benefits obtained.

6. Tornado Charts

Similar to gain/loss curves, tornado charts attempt to capture how much of an impact a risk has on a particular parameter such as revenue, net income, or earnings per share.

7. Risk Corrected / Adjusted Revenues

Risk-adjusted (or risk-corrected) revenues allow management to see how revenues could look if risks were managed better. Risk-corrected revenues are smoother and more controllable. Risk-corrected revenues also produce a tighter distribution of earnings. A tighter distribution of earnings could potentially lead to improved performance of its stock price. While stakeholders (e.g., investors) appreciate growth in earnings, they also appreciate some level of stability and predictability and are often willing to pay a premium for these attributes

8. Earnings at Risk

Earnings at risk are determined by examining how earnings vary around expected earnings. In this approach, variables are examined to see how they influence earnings, such as determining the influence that a one-point movement in interest rates would have on earnings. Similarly, expected or budgeted cash flows can be determined and then tested for sensitivity to certain risks. Some companies trace the earnings-at risk to individual risk sources. Knowing the actual root cause or source of the risk helps to manage it more efficiently. Companies can also trace the earnings-at-

risk to business units to help gauge the hedge effectiveness of each business unit. Knowing which business units have the greatest risk is valuable information. With this knowledge, a company could compare a business unit's earnings level to the earnings-at-risk. Those units that generate low earnings and high levels of risk may not be desirable business units. Having earnings-at-risk in the aggregate allows an organization to see which months have the greatest risk. Also, distributions can be created that estimate the probability of meeting earnings targets.

4.4 Risk likelihood and impact evaluation

Risk evaluation is a pivotal step within the broader risk management process, involving the assessment of two key factors: the likelihood of a risk occurring and the potential impact it could have. Effectively evaluating these aspects is crucial for informed decision-making and proactive risk mitigation.

4.4.1 Evaluating Likelihood

Likelihood refers to the probability or chance that a specific risk event will materialize. It quantifies how often a risk may occur, often expressed as a percentage or in qualitative terms (e.g., low, medium, high).

Likelihood information can be obtained through; Past occurrences or data that can inform assessments of likelihood (Historical Data), Input from subject matter experts can help gauge likelihood (Expert Opinions), and External conditions, such as economic trends or natural phenomena, may influence the likelihood of certain risks (Environmental Factors)

4.4.2 Evaluating Impact

Impact refers to the potential consequences or magnitude of a risk event if it does occur. Impact can manifest in various ways, including financial losses, operational disruptions, reputational damage, or regulatory non-compliance.

Impact can be assessment through the following methods: Expert judgment and qualitative descriptors (e.g., low, moderate, high) can help categorize impact (Qualitative Assessment), Using financial models, simulations, or historical data to assign numerical values to impact (Quantitative Assessment, and Exploring various scenarios and conducting sensitivity analysis can help understand the range of potential impacts, accounting for uncertainties (Scenarios and Sensitivity

Analysis).

4.4.3 Integration of impact and Likelihood

This can be done with the help of the following tools:

- **Risk Matrix:** Combining likelihood and impact assessments in a risk matrix helps visualize and prioritize risks effectively. This matrix categorizes risks into categories such as high/medium/low risk.
- **Risk Tolerance:** Aligning the evaluation results with an organization's risk tolerance is critical. It ensures that risks are managed in line with the organization's risk appetite and strategic objectives.
- **Risk Scoring Models:** Many organizations use risk scoring models that combine likelihood and impact assessments to assign a numerical score to each risk. These scores can help prioritize risks systematically.

4.5 Risk Tolerance and Risk Appetite

Risk Tolerance is the degree of uncertainty or potential loss that an individual or organization is willing to accept in pursuit of its goals and objectives. It represents the level of risk that is deemed acceptable. *Risk appetite* is a broader, strategic-level concept that defines the overall willingness of an organization to take on risk to achieve its objectives. It reflects the organization's culture, values, and strategic vision.

Risk tolerance is a subjective concept and can vary widely from person to person or from one organization to another. It depends on factors such as risk perception, risk aversion, financial capacity, and strategic objectives. Risk tolerance is often categorized into levels such as conservative, moderate, and aggressive. Conservative investors or organizations prefer low-risk, low-return strategies, while aggressive ones are more willing to take on higher risks for potentially higher rewards. Risk tolerance is not static and may change over time. It should be periodically reassessed to account for changes in financial circumstances, goals, and risk perceptions.

4.5.1 Factors Influencing Risk Tolerance:

- **Financial Capacity**: The financial resources available to absorb potential losses play a significant role in determining risk tolerance.
- **Risk Perception**: An individual's or organization's perception of risk can influence their

willingness to accept it. Some may be more risk-averse, while others may be more risk-tolerant.

- **Time Horizon**: Longer time horizons often lead to greater risk tolerance as there is more time to recover from potential losses.
- **Strategic Goals**: Risk tolerance is closely tied to an entity's strategic goals. Organizations may be willing to accept higher risks in pursuit of aggressive growth objectives.

4.5.6 Risk Tolerance vs. Risk Appetite

While risk tolerance focuses on individual risk levels, risk appetite looks at the collective risk-taking capacity of an organization. Risk tolerance may vary among different units or individuals within an organization, but risk appetite sets an overarching framework.