# Risk Analysis in Agricultural Enterprises

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**تحليل المخاطرة في المشروعات الزراعية**

**خلاصة:**

إن التحديات التي تواجه الزارعة هي كثيرة ومتنوعة. وتتمثل الأولوية الزراعية بالنسبة إلى جميع النظم الزراعية بزيادة الغلة الإنتاجية و التقليل من المخاطرة قدر الإمكان، حيث تعتبر المنفعة هي الأكثر أهمية في المشروعات الزراعية كما في غيرها من المشروعات الاستثمارية، لذلك يعتبر تحديد المخاطرة للمشروعات الاستثمارية و بخاصة الزراعية منها من أهم الخطوات بالنسبة لعملية صنع القرار بحيث يتم اختيار المشروع ذو مستوى المخاطرة الأقل.

إن التعامل مع المخاطرة يعتبر صعب و فيه الكثير من التناقض الى حد ما،سواءً بالنسبة للمزارعين أو متخذي القرار على حد سواء ، احد أسباب ذلك يرجع الى التناقض والاختلاف في الرأي حول ماهية المخاطر المحدقة بالمشروع الزراعي حيث تتعدد مصادر المخاطرة متمثلة بالمدخلات الزراعية والعوامل الجوية و غيرها و الأخر هو كيفية قياسها.

لذلك الهدف الأول للبحث هو دراسة مفهوم قياس المخاطرة و ذلك بشكل مبسط بعيد عن التعقيد و الهدف الأخر هو تقديم المعايير المستخدمة في اتخاذ القرار للمشروعات الاستثمارية و الأسس التي يبنى علها اتخاذ القرار و من ثم النتائج .

**الكلمات المفتاحية**: تحليل المخاطرة، اتخاذ القرار، المشروعات الزراعية، المنافع، الاحتمالية

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## 1. Introduction

Risk analysis has become increasingly popular in recent years. Therefore، identify some of the main areas of difficulty and possible confusion and to suggest more theoretically sound concepts and practicable methods.

Accounting for risk in the analysis of farming systems is much harder than pretending it doesn't exist. In the past، the difficulties have been compounded by confusion over just what risk is and how it can be measured.

Risk analysis in agriculture has faltered in the past because of difficulties in estimate and categorizing farmers' attitudes to risk. It is argued that risk aversion may not be as important for some choices as commonly believed; there are some rough and ready ways to estimate the relevant range of the risk for some target group. Methods of stochastic efficiency analysis then allow at least something to be said about better and worse solutions.

Some risk analyses that have been based on the assumptions about the degree of risk aversion has overlooked some of the complexity in making the move from utility of wealth to utility of gains and losses or the utility of income. Moreover، very few such analyses have recognized that risk aversion for permanent income is likely to be much more important than is risk aversion for temporary income.

Risk analysis has also been avoided in the past because so many would-be analysts were afraid to tackle the evaluation of risky choices when too few hard data were available to work out the required probability distributions. Too many of those who braved the waters of risk analysis left untold or under-emphasized the dubious relevance to the problem at hand of the data they used to represent uncertainty. It seems that the task of finding better ways to deduce the probability distributions that describe the risks that farmers face has been relatively neglected by agricultural economists.

## 2. Background

Risk is a fundamental component of agricultural production and various studies of farmers' attitudes to risk have generally found that farmers are risk averse (Chavas and Holt 1990 and Pope and Just 1991).Risk analysis is quite a young discipline، the base of which was established by Knight، in 1933. After some decades the structure of risk analysis was very similar in the books of Raiffa (1968) and Schlaifer (1959، 1969). Risk analysis started to improve dinamically in the end of the 70s which can be noticed in the books of the 80s with the main principles of the field (Barry (1984)، Lindley (1985)، Robison and Barry (1987)، illetve Gregory (1988)). In some works the risk of agriculture is considered with high relevance (Halter and Dean (1971)، Dillon (1971)).Risk analysis is surveyed with deep mathematical tools in Spetzler and von Holstein (1975)، Smith (1988)، Smith and Mandac (1995) and Pratt et al. (1995).The book of Anderson et al. (1977) is mighty comprehensive with several agricultural applications and the operation research aspects are considered as well.In Clemen (1996) a general description of modern risk analysis with data management and decision analysis can be found.Just (2003) gives an outlook to the possible improvements in the following 25 years، especially with respect of agricultural risk. The book of Hardaker et al. (2004) is an excellent monograph in which there is a special emphasis on agricultural risk.

**3. Defining the Risk**

Many definitions of ‘risk’ exist (Kelman 2003; Thywissen 2006). Risk is defined by the risk management standard AS/NZS 4360:2004 as (p. 4):

‘The chance of something happening that will have an impact on objectives. A risk is often specified in terms of an event or circumstance and the consequences that may flow from it. Risk is measured in terms of a combination of the consequences of an event and their likelihood.’

‘Likelihood’ describes how often a hazard is likely to occur، and is commonly referred to as the probability or frequency of an event. ‘Consequence’ describes the effect or impact of a hazard on a community. Both likelihood and consequence may be expressed using either descriptive words (i.e. qualitative measures) or numerical values (i.e. quantitative measures) to communicate the magnitude of the potential impact (AS/NZS 4360:2004).

In Agriculture. According to White (1994)، agronomists and engineers (for instance Nash and Nash، 1995) tend to define risk as a loss، while economists tend to use the word as a synonym of "probability of occurrence of a damaging event".

Even supposed experts use the term 'risk' in several different ways، these differences cause considerable confusion especially when systematic efforts are made to measure risk and to evaluate it. Among the many usages of the word، three common interpretations are:

1. The chance of a bad outcome;
2. The variability of outcomes; and
3. Uncertainty of outcomes.

Although seemingly similar، these three definitions imply quite different ways of measuring risk. Moreover، when formally defined they can be seen to be mutually inconsistent. It will be argued here that، while the first two meanings are in common usage، clarity is best served by defining risk، at least for formal analyses، as the uncertainty of outcomes.

**4. Decision criteria**

By using a discount rate that allows for risk، investment decision criteria normally used in deterministic analysis maintain their validity and comparability. The expected value of the probability distribution of NPV (see Measures of risk below) generated using the same discount rate as the one used in conventional appraisal is a summary indicator of the project worth which is directly comparable (and should indeed be similar to) the NPV figure arrived at in the deterministic appraisal of the same project. Through the expected value of the NPV distribution therefore the decision criteria of investment appraisal still maintain their applicability.

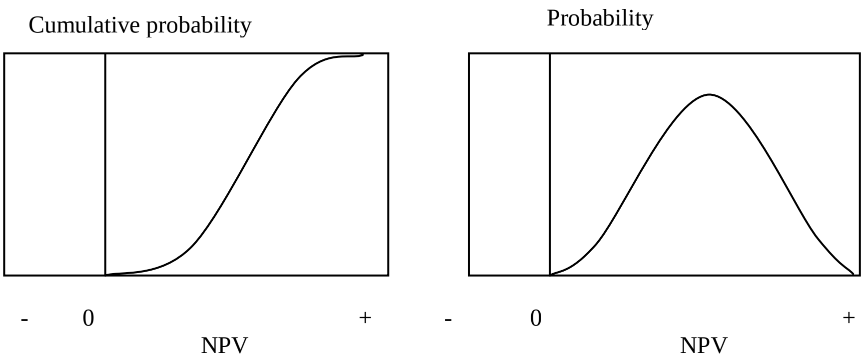
However، because risk analysis presents the decision maker with an additional aspect of the project – the risk/return profile – the investment decision may be revised accordingly. The final decision is therefore subjective and rests to a large extent on the investor's attitudes towards risk.

The general rule is to choose the project with the probability distribution of return that best suits one's own personal predisposition towards risk. The "risk-lover" will most likely choose of invest in projects with relatively high return، showing less concern in the risk involved. The "risk-averter" will most likely choose to invest in projects with relatively modest but rather safe returns.

However، assuming "rational" behavior on behalf of the decision maker the following cases may be examined. Cases 1، 2 and 3 involve the decision criterion to invest in a single project. Cases 4 and 5 relate to investment decision criteria for choosing between alternative (mutually exclusive) projects.

In every case examined both the cumulative and non-cumulative probability distributions are illustrated for comparison purposes. The cumulative probability distribution of the project returns is more useful for decisions involving alternative projects while the non-cumulative distribution is better for indicating the mode of the distribution and for understanding concepts related to expected value.

Case 1: The minimum point of the probability distribution of project return is higher than Zero NPV (Figure 1).

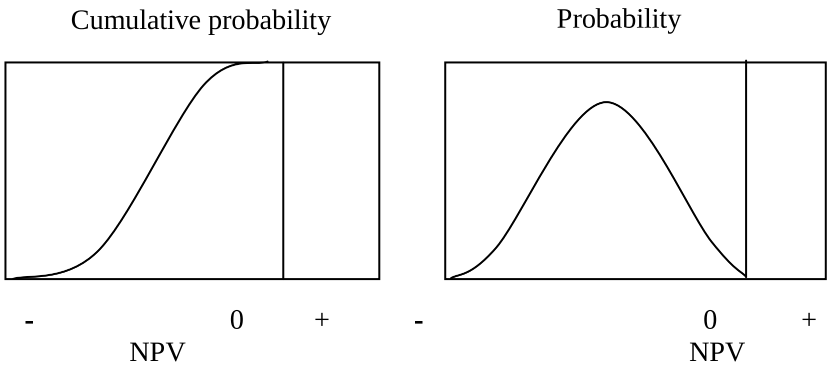



DECISION: ACCEPT

Figure 1Case 1: Probability of negative NPV=0

Since the project shows a positive NPV even under the "worst" of cases then clearly the project should be accepted.

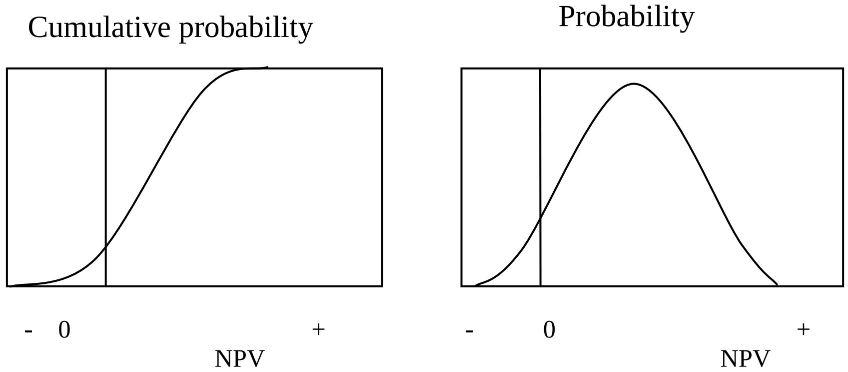
Case 2: The maximum point of the probability distribution of project return is lower than zero NPV (Figure 2).Since the project shows a negative NPV even under the “best” of cases (no probability for positive return) then clearly the project should be rejected.




DECISION: REJECT

Figure 2 Case 2: Probability of positive NPV=0

Case 3: The maximum point of the probability distribution of project return is higher and the minimum point is lower than zero Net Present Value (the curve intersects the point of zero NPV – Figure 3).

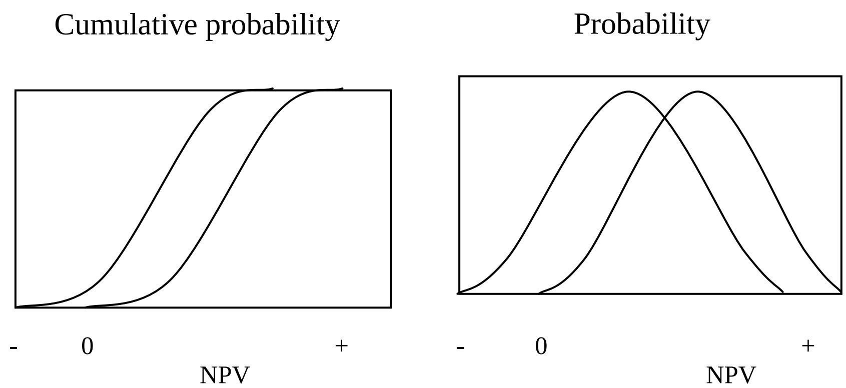



DECISION: ACCEPT

DECISION: INDETEMINATE

Figure 3 Case 3: Probability of zero NPV greater than 0 and less than 1

Case 4: Non-intersecting cumulative probability distributions of project return for mutually exclusive projects (Figure 4).




DECISION: CHOOSE PROJECT B

Figure 4 Case 4: Mutually exclusive projects

(Given the same probability، one project always shows a higher return)

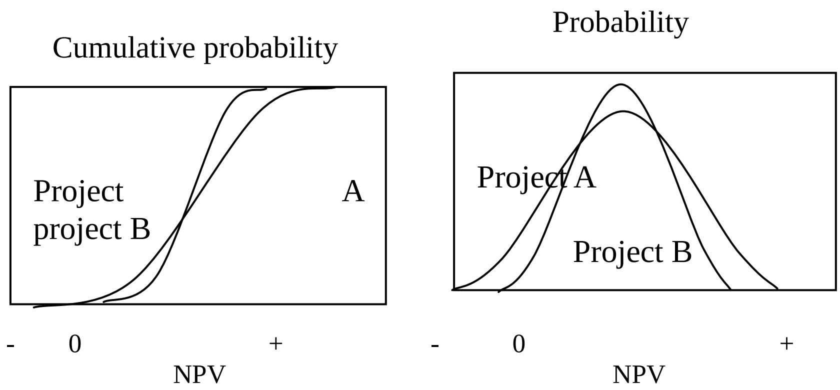
Given the same probability، the return of project B is always higher than the return of project A. Alternatively، given one particular return، the probability that it will be achieved or exceeded is always higher by project B than it is by project A. Therefore، we can deduce the first rule for choosing between alternative projects with risk analysis as:

Rule 1: If the cumulative probability distributions of the return of two mutually exclusive projects do not intersect at any point then always choose the project whose probability distribution curve is further to the right.

Case 5: Intersecting cumulative probability distributions of project return for mutually exclusive projects (Figure 5).

Risk “lovers” will be attracted by the possibility of higher return and therefore will be inclined to choose project A. Risk “averters” will be attracted by the possibility of low loss and will therefore be inclined to choose project B.

Rule 2: If the cumulative probability distributions of the return of two mutually exclusive projects intersect at any point then the decision rests on the risk predisposition of the investor.




DECISION: INDETERMINATE

Figure 5 DECISIONS: INDETERMINATE

(Note: With non-cumulative probability distributions a true intersection is harder to detect because probability is represented spatially by the total area under each curve.)

**5. Measuring risk**

Let’s look at each of the above definitions in turn to see how risk might be measured for each. ‘The chance of a bad outcome’ implies the probability of some defined unsatisfactory outcome happening. Assume for simplicity that there is a single measure of outcome، X، more of which is always preferred to less. This definition of risk might be represented by the probability P* = P(X < X*)، where P is probability، X is the uncertain outcome، and X* is some cut-off or minimally acceptable outcome level below which outcomes are regarded as ‘bad’. In some cases، the value of X* might reflect some disaster level such as ‘starvation’ or ‘bankruptcy’، but in most cases it may be a less clear-cut notion، so that application of this measure of risk requires specification of the two parameters P* and X*.

Risk as variability may be measured by some statistic of dispersion of the distribution of outcomes، such as the variance or standard deviation of X، V = V[X] or SD، equal to the positive square root of V. Obviously، neither statistic alone tells anything about the location of the distribution of outcomes on the X axis. So it is common for those who think of risk as dispersion of outcomes to link V or SD with the mean or expected value E = E[X]. Then variance may be described as the risk around the specified mean. Building on this notion، some authors، such as Newbery and Stiglitz (1981)، have found it convenient to reflect risk using the coefficient of variation of X، CV = SD/E.

Finally، adopting the definition of risk as the distribution of outcomes requires the whole distribution of X to be specified. Complete specification requires the probability density function، f(X)، or equivalently and often more conveniently، the cumulative distribution function F(X). However، summary statistics including moments are commonly used to describe the probability distribution، implying some similarity with the measurements based on the definition of risk as dispersion. For a few special cases، such as the normal، the distribution of outcomes is fully defined by only the mean and variance. Other distributions might be approximated in terms of these first two moments، though higher order moments may be needed to tell more about the shape of the distribution. For some arbitrary distribution، however، description by moments will be an approximation the adequacy of which is not easily judged.

The weakness of the first two definitions of risk as defined previously with their associated measures is that neither 'tells the whole story' when a choice has to be faced amongst risky alternatives. In regard to the first definition، it is clear from observing behavior that not all risks with bad outcomes are rejected. For example، most people will travel by car for sightseeingan activity that certainly increases the probability of death or serious injury in a road accident. Evidently، choices with chances of very bad outcomes (e.g. death or serious injury) are sometimes accepted، presumably because the benefits of the up-side consequences (e.g. seeing interesting sights) are sufficiently appealing to offset the relatively low chances of the bad outcome. It follows that to evaluate or assess a risk we need to be able to consider the whole range of outcomes، good and bad، and their associated probabilities. Descriptions of risk expressed in terms of only the probability in the lower tail of the distribution of outcomes do not provide full information for proper risk assessment، and so may be seriously misleading.

A similar argument shows the limitation of variance alone as a measure for risk evaluation. Consider two normal distributions of outcomes of، say، and net income، with identical variances but different means. Everyone will prefer the one with the higher mean. Moreover، many would describe the distribution located further to the right as the less risky of the two since the chance of getting less than any specified level of X is lower for this distribution than for the one with the lower mean2. On the other hand، using variance as the measure of risk suggests that the two distributions are equally risky. Clearly، we could avoid such confusion by interpreting measures of dispersion or stability simply as what they are، and not regarding them as 'stand alone' measures of risk.

If risk is defined as variance but is always interpreted in conjunction with the mean، this definition might seem to be similar to defining risk as the distribution of outcomes but then using an EV approximation of the distribution. But the problem inherent in defining risk as variance already noted still remains. Not all shifts in E،V space that reduce variance will lead to more preferred E،V combinations for a risk-averse decision maker (DM); if both E and V are reduced، the effect on preference is indeterminate unless the degree of risk aversion is known. Hence، it seems unwise and potentially confusing to describe every prospect with lower variance as ‘less risky’.

Adopting the third option of defining risk as the full distribution of outcomes means that here is no one statistic that can be used to measure risk، so that it becomes impossible to compare distributions in terms of their ‘riskiness’. While this might seem to make the notion of risk elusive، in fact، the absence of such a single measure proves to be no impediment to the comparative assessment of alternative risky prospects، as discussed below. What this third view of risk implies is that notions of ‘more’ or ‘less’ risk (‘more risky’ versus ‘less risky’ prospects) are unsatisfactory، and careful analysts will confine themselves to describing risky prospects as 'preferred' versus 'not preferred'، or as 'risk efficient' versus 'not risk efficient'.

As a stochastic variable، risk can be measured by measures such as the Expected Value (EV)، the Standard Deviation (SD) or Numerical Value of risk and the risk Coefficient of variability described as follows.

**5.1. Expected value (EV)**

The EV is also called the mean or average. It is represented as E(x) or μ. The equations of EV are as follows:

$$E(X) = \sum_{i=1}^{n} p_i x_i \qquad (1)$$

For discrete variables

$$E(X) = \int_{-\infty}^{+\infty} x f(x) d(x) \qquad (2)$$

For continuous variables

Where: X is stochastic variable

Xi is the numerical value of number i

$P_i$ is the probability of the stochastic variable $x_i$

n is the number of stochastic variable

The EV is the objective (unbiased) value to represent a probability distribution. An EV of a risk event represents the most likely outcome of the risk event under certain expectations of the underlying probabilities distribution. If a developer has sufficient historical data، the actual loss of the event، viz. the loss occurrence of the risk event will approach the EV of loss if the event were to occur many times. Otherwise the reliability of the EV of loss gained according to the theory will be lower.

The expected value statistic summaries the information contained within a probability distribution. It is a weighted average of the values of all the probable outcomes. The weights are the probabilities attached to each possible outcome. In risk analysis as applied in project appraisal the expected value is the sum of the products of the generated project returns and their respective probabilities. This is illustrated in the simple example of a project with four possible returns and probabilities:

Table 1 calculating the EV

| Return( R) | Probability (P) | Expected value (EV) |
|---|---|---|
| -20 | 0.1 | -2 |
| -10 | 0.2 | -2 |
| -5 | 0.2 | -1 |
| 10 | 0.3 | 3 |
| 20 | 0.2 | 4 |
| total | | 2 |

The expected value of the above project is 2.0. This is derived by multiplying each return by its respective probability and summing the results. The total of all the negative returns times their respective probability is the expected loss from the project. In the above example this amounts to -5 (which is the sum of the “probability weighted” negative returns). The total of all the positive returns times their respective probability is the expected gain from the project. In the above example this amounts to 7 (which is the sum of the "probability weighted" positive returns).

The expected value is، of course، the total of expected gain and expected loss. The expected value statistic aggregates into a single number all the information that is depicted in a multi-valued probability distribution. Being a summary measure is therefore only a gross indicator of a project's worth. Measures of risk that employ expected value concepts are the "cost of uncertainty"، the “expected loss ratio” and the “coefficient of variation”; it is also used to analyses risk under conditions of limited liability.

Riskness in particular project or the company portfolio risk usually can be analyzed by running three common methods of risk analysis: method of probability distribution; method of simulation; and method of sensitivity analysis.

## 5.2. Method of probability distribution

Risk is associated with variability of returns expected. So، the more variable are the expected future returns، the riskier is the investment or project، and vice versa.

However، it is useful to define risk more precisely. In the case of any investment decision or any kind of business decision، it has to be done forecast of future events. Probability expectation could be defined or measured from the point views of a project analyst، or as an expectation of each possibly outcome. In its simplest form، a probability distribution could consists of an optimistic، pessimistic and most likely estimate or alternatively، high (boom)، low (recession) and a "best guess" (normal market conditions) estimates. Such examples could be illustrated as it is shown below table 2 (example 1):

Table 2: Pay-off matrix for Project X and Project Y

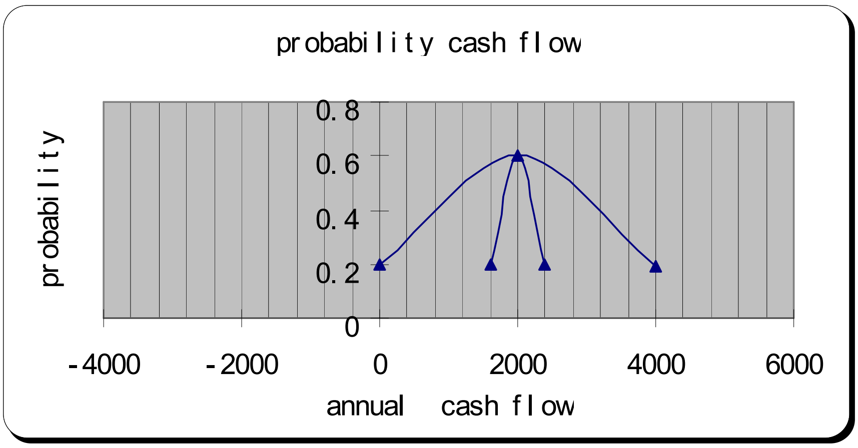
| **item** | **annual cash flow** | |
|---|---|---|
| | **project X** | **project Y** |
| boob (high) | 2400 | 4000 |
| normal (most likely) | 2000 | 2000 |
| recession (low) | 1600 | 0 |

The probability expectation in the example is: in case of boom is 0.2، in normal conditions is 0.6، and probability of recession is 0.2. Given the annual cash flows under the three possible states of the future market and their probability of occurring، weighted average projected cash flows can be calculated by multiplying each cash flow by its probability of occurrence. This is shown in the example below table 3 (example 2):

Table 3: Calculation of expected values

| Appraisal | CF | P | EV |
|---|---|---|---|
| **Project X** | | | |
| boob (high) | 2400 | 0.2 | 480 |
| normal (most likely) | 2000 | 0.6 | 1200 |
| recession (low) | 1600 | 0.2 | 320 |
| Project Y | | | |
| boob (high) | 4000 | 0.2 | 800 |
| normal (most likely) | 2000 | 0.6 | 1200 |
| recession (low) | 0 | 0.2 | 0 |

Calculated average value is defined as expected value of cash flow in particular investment or any business operation of the agricultural enterprise. Also، it could be stated as a basic result in comparison with the values created through alternative business decisions. Business risk is existing always due to the particular investment and could be presented in graphical form to obtain a clear picture of variability of actual outcomes (Graph 1).




Looking at the net cash flow (which is equal in both cases); one is temped to rank both investments equally. But a look at the graph above shows that the variability of cash flows for Py is greater than of Px and therefore the project Py is Riskier project.

## 5.3 Standard Deviation (SD) or Numerical Value of Risk

SD is the square root of another statistic called the variance (σ2). Variance (σ2) is the EV of the squared difference between possible outcomes and the mean。

$$\delta^2 = \sum_{i=1}^{n} p_i (x_i - \mu)^2 = E[((x_i - \mu)^2] \qquad (3)$$

For discrete distribution

Where E ( ) is a common representation for the EV of whatever is inside the parentheses.

The variability of distribution is normally measured by standard deviation. The earlier example is used to calculate the standard deviation as presented below table 4 (example 3).

Columns 1، 2 and 3 are taken directly from previous example. In column 4، that expected value from each possible outcome is subtracted to derive the deviations about the expected value. In column 5، deviations are squared. In column 6، squared deviation is multiplied by associated probability and the products are summed to obtain that variance of the probability distribution.

The calculation provide outcomes for Px = 252.98 and Py = 264.91 So، it could be stated that the project Py is more risky than project Px.

Table 4: Calculation of standard deviation and variance

| **P** | **CF** | **EV** | **D** | **SD** | **V 1*5** |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| **Project** A | | | | | |
| 0.2 | 2400 | 480 | 400 | 160000 | 32000 |
| 0.6 | 2000 | 1200 | 0 | 0 | 0 |
| 0.2 | 1600 | 320 | -400 | 160000 | 32000 |
| **EV** | **2000** | | | **variance** | **64000** |
| | | | | **SD** | **252.98** |
| **Projet B** | | | | | |
| 0.2 | 4000 | 800 | 2000 | 4000000 | 800000 |
| 0.6 | 2000 | 1200 | 0 | 0 | 0 |
| 0.2 | 0 | 0 | - | 4000000 | 800000 |
| **EV** | **2000** | | | **variance** | **1600000** |
| | | | | **SD** | **1264.91** |

### 5.4 Risk Degree or Coefficient of Variability

The equation of Risk Degree (RDg) is as follows:

$$RDg = \frac{\sigma}{E(x)} \qquad (4)$$

Where RDg is RDg/ coefficient of variability σ is SD and E(x) is EV

Applying the last equation:

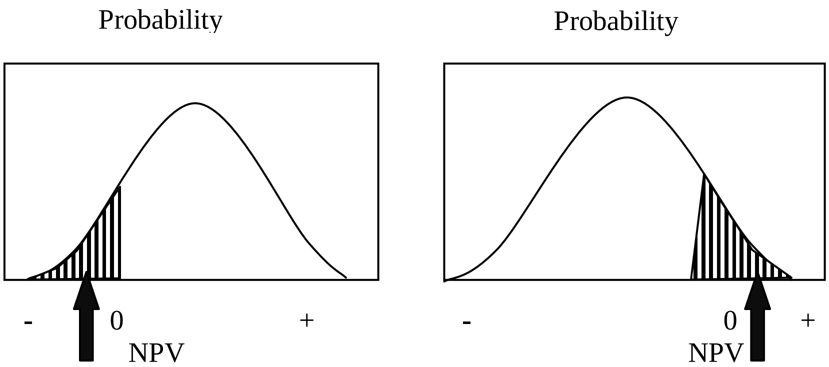
RDg (A)=252.98/2000=0.126
RDg (B) = 1264.91/2000=0.632

RDg or coefficient of variability is a very good measure for comparing when the EVs of different schemes are not approximately the same. It will be used to represent the degree of a risk of RD. The larger the RDg of variability is، the greater the risk is، so RDg (B)> RDg (A)، then project B is more risky than project A as shown when it measured buy the SD conception.

## 5.5 Cost of uncertainty

The cost of uncertainty، or the value of information as it is sometimes called، is a useful concept that helps determine the maximum amount of money one should be prepared to pay to obtain information in order to reduce project uncertainty. This may be defined as the expected value of the possible gains foregone following a decision to reject a project، or the expected value of the losses that may be incurred following a decision to accept a project. The expected gain forgone from rejecting a project is illustrated in the right-hand diagram of Figure 6 by the sum of the possible positive NPVs weighted by their respective probabilities. Similarly، the expected loss from accepting a project، indicated in the left-hand diagram، is the sum of all the possible negative NPVs weighted by their respective probabilities.

By being able to estimate the expected benefit that is likely to result from the purchase of more information، one can decide on whether it is worthwhile to postpone a decision to accept or reject a project and seek further information or whether to make the decision immediately. As a general rule one should postpone the investment decision if the possible reduction in the cost of uncertainty is greater than the cost of securing more information (including foregone profits if the project is delayed).




Expected value of possible loss From accepting a project

Expected value of gain foregone from rejecting a project

Figure 6 Expected value possible loss and gain foregone

### *5.6 Expected loss ratio*

The expected loss ratio (el) is a measure indicating the magnitude of expected loss relative to the project's overall expected NPV. This is expressed in the formula absolute value of expected loss divided by the sum of expected gain and absolute value of expected loss:

$$el = \frac{|el|}{eg + |el|} \qquad (5)$$

It can vary from 0، meaning no expected loss، to 1، which means no expected gain. Diagrammatically، this is the probability weighted return derived from the shaded area to the left of zero NPV divided by the probability weighted return derived from the total distribution whereby the negative returns are taken as positive (see figure 7).

A project with a probability distribution of returns totally above the zero NPV mark would compute an el value of 0، meaning that the project is completely unexposed to risk. On the other hand، a project with a probability distribution of returns completely below the zero NPV mark would result in an el of 1، meaning that the project is totally exposed to risk. The ratio does not therefore distinguish between levels of risk for totally positive or totally negative distributions. However، within these two extreme boundaries the el ratio could be a useful measure for summarizing the level of risk to which a project may be subjected. In the above example، From equation (5)the expected loss ratio is $el = \frac{|el|}{eg + |el|} = \frac{5}{5+7} = 0.41$ 5 / (5+7) .

Other methods for determining the risk exposure of a project's probability distribution of returns are possible. Such measures would vary depending on how one defines risk and on the emphasis one places on its major components. The el ratio is offered as an example of how one can use the results of risk analysis to assess and summaries the risk inherent in a project. The el ratio defines risk to be a factor of both the shape and the position of the probability distribution of returns in relation to the “cut-off” mark of zero NPV.

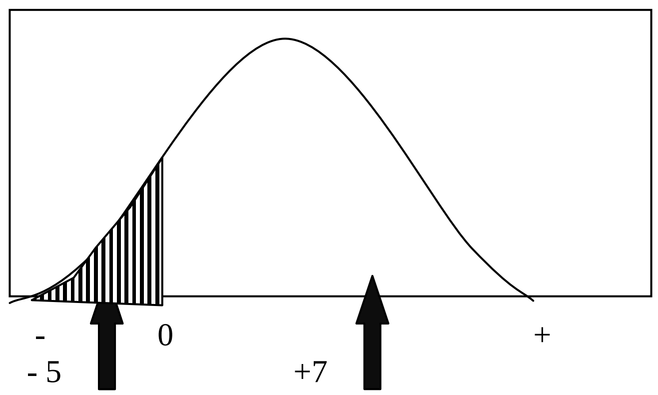



Figure 7 Expected value possible loss and gain foregone

## 5.6 Coefficient of variation

The coefficient of variation is also a useful summary measure of project risk. It is the standard deviation of the projected returns divided by the expected value. Assuming a positive expected value، the lower the coefficient of variation the less the project risk. Conditions of limited liability the extent of maximum loss possible under conditions of limited liability is usually defined by the legal agreements entered into by the various parties involved in a project. Looking at the investment in terms of present value the equity holders cannot lose more than the present value of their equity capital، the debt holders can only lose the present value of their loan capital، the creditors the present value of the extended credit and so on. Consider the probability distribution of the return of a project as depicted in Figure 8.

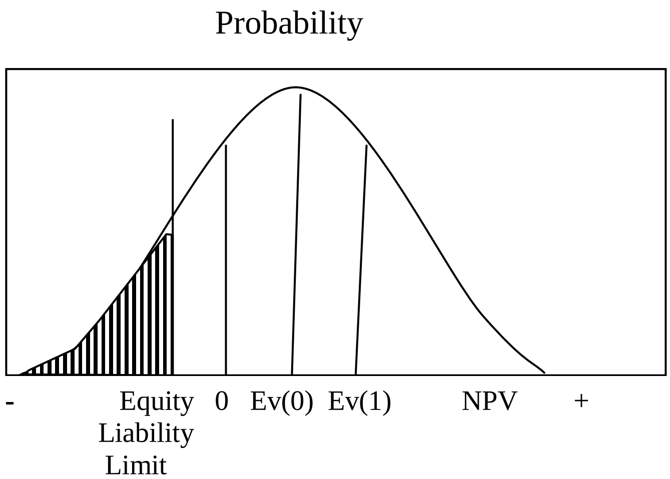



Figure 8. Risk under conditions of limited liability

From the equity holders' point of view the tail of the distribution، which is beyond their maximum liability limit as defined by the present value of equity capital invested in the project، is not relevant. The probability of the project for generating a return lower than their maximum liability limit is therefore reassigned to the point of equity liability limit as shown in the diagram. This adjustment also has the effect of raising the expected value of the project from the point of view of the equity holders، from Ev(0) to Ev(1).

## 6. SENSITIVITY ANALYSES

### 6.1 The Purpose of Sensitivity Analysis

Sensitivity of NPV to the project lifetime is more specifically because there is not linear function between NPV and project lifetime. We only could estimate NPV assuming the presumption of delay of the project's implementation.

Sensitivity of NPV to the project discount rate is estimated as a difference between IRR and WACC. The higher is the difference between IRR and the cost of capital، the less sensitive is the NPV to the discount rate، and the less risky is the project

Sensitivity analysis is a technique for investigating the impact of changes in project variables on the base-case (most probable outcome scenario). Typically، only adverse changes are considered in sensitivity analysis. The purpose of sensitivity analysis is:

(i) To help identify the key variables which influence the project cost and benefit streams، in this empirical example key variables to be normally included in sensitivity analysis include investment cost، financial revenues، economic benefits، financial benefits، and discount rates.

(ii) To investigate the consequences of likely adverse changes in these key variables;

(iii)To assess whether project decisions are likely to be affected by such changes; and،

(iv)To identify actions that could mitigate possible adverse effects on the project.

### 6.2 Performance of Sensitivity Analysis

Sensitivity analysis needs to be carried out in a systematic manner. To meet the above purposes، the following steps are suggested:

identify key variables to which the project decision may be sensitive;

(ii) Calculate the effect of likely changes in these variables on the base-case IRR or NPV، and calculate a sensitivity indicator and/or switching value;

(iii) Consider possible combinations of variables that may change simultaneously in an adverse direction;

(iv) Analyze the direction and scale of likely changes for the key variables identified، involving identification of the sources of change.

### 6.2.1 Step 1: Identifying the Key Variables

The base case project economic analysis incorporates many variables: quantities and their inter-relationships، prices or economic values and the timing of project effects. Some of these variables will be predictable or relatively small in value in the project context. It is not necessary to investigate the sensitivity of the measures of project worth to such variables. Other variables may be less predictable or larger in value. Variables related to sectoral policy and capacity building may also be important. As they are more difficult to quantify، they are not further considered hereafter but should be assessed in a qualitative manner.

As a result of analysis of the project context، a preliminary set of likely key variables can be chosen on the following basis:

(i) Variables which are numerically large. For example: investment cost، projected water demand;

(ii) Essential variables، which may be small، but the value of which is very important for the design of the project. For example: assumed population growth and water tariffs;

(iii) Variables occurring early in the project life. For example: investment costs and initial fixed operating costs، which will be relatively unaffected by discounting;

(iv) Variables affected by economic changes، such as، changes in real income.

### 6.2.2 Step 2 and 3: Calculation of Effects of Changing Variables

The values of the basic indicators of project viability (EIRR and ENPV should be recalculated for different values of key variables. This is preferably done by calculating "sensitivity indicators" and "switching values". The meaning of these concepts is presented in table 5 and a sample calculation immediately follows. Sensitivity indicators and switching values can be calculated for the IRR and NPV، as in the next table

**table 5 Use of Sensitivity Indicators and Switching Values**

| | Sensitivity Indicator | Switching Value |
|---|---|---|
| Definition | 1. Towards the Net Present Value Compares percentage change in NPV with percentage change in a variable or Combination of variables.<br>2. Towards the Internal Rate of Return Compares percentage change in IRR above the cut-off rate with percentage change in a variable or combination of variables | 1. Towards the Net Present Value The percentage change in a variable or combination of variables to reduce the NPV to zero (0).<br>2. Towards the Internal Rate of Return The percentage change in a variable or combination of variables to reduce the IRR to the cut-off rate (=discount rate). |
| Expression | 1.Towards the Net Present Value<br>$SI = \frac{(NPVb - NPV1) / NPVb}{(Xb - X1) / Xb}$<br>where: Xb - value of variable in the base case;X1 - value of the variable in the، sensitivity test;NPVb - value of NPV in the base case;NPV1 - value of the variable in the sensitivity test<br>2. Towards the Internal Rate of Return<br>$SI = \frac{(IRRb - IRR1) / (IRRb – d)}{(Xb - X1) / Xb}$<br>where: Xb - value of variable in the base case;X1 - value of the variable in the; sensitivity test IRRb - value of IRR in the base case ;IRR1Value of the variable in the sensitivity test<br>d - discount rate | 1. Towards the Net Present Value<br>$SV = \frac{100 \times NPVb}{(NPVb - NPV1)} \times \frac{(Xb – X1)}{Xb}$<br>where: Xb - value of variable in the base case;X1 - value of the variable in the sensitivity test;NPVb – value of NPV in the base case;NPV1 – value of the variable in the sensitivity test<br>2. Towards the Internal Rate of Return<br>$SV = \frac{100 \times (IRRb – d)}{(IRRb - IRR1)} \times \frac{(Xb – X1)}{Xb}$<br>where: Xb - value of variable in the base case; X1 - value of the variable in the sensitivity test; IRRb - value of IRR in the base case IRR1 – value of the variable in the sensitivity test<br>d - discount rate |

| | | |
|---|---|---|
| Calculation example | 1. Towards the Net Present Value Base Case:<br>Price = 300<br>NPVb = 20،912<br>Scenario 1:<br>P1 = 270 (10% change)<br>NPV1 = 6،895<br>(20،912 – 6،895) / 20،912<br>SI = ---------------------------- =<br>(300 – 270) / 300<br>6.70<br>2. Towards the Internal Rate of Return Base Case:<br>Price = Pb = 300،IRRb = 15.87%<br>Scenario 1:<br>P1 = 270 (10% change)<br>IRR1 = 13.31%<br>d = 12%<br>(0.1587–0.1331)/ (0.1587- 0.12)<br>SI = ----------------------------------<br>(300 – 270) / 300<br>=6.61 | 1. Towards the Net Present Value Base Case:<br>Price = Pb = 300<br>NPVb = 20،912<br>Scenario 1<br>P1 = 270 (10% change)<br>NPV1 = 6،895<br>(100 x 20،912) (300-270)<br>SV = ------------------ x ----------- =<br>(20،912 – 6،895) 300<br>14.9%<br>2. Towards the Internal Rate of Return Base Case:<br>Price = Pb = 300،IRRb = 15.87%<br>Scenario 1:<br>P1 = 270 (10% change)<br>IRR1 = 13.31%<br>d = 12%<br>(100x(0.1587-0.12))(300-270)<br>SV= ------------------------- x<br>(0.1587 - 0.1331) 300 |
| Interpretation | (i) percentage change in NPV respectively<br>(ii) Percentage change in IRR above the cut-off rate (12%) is larger than percentage change in variable: price is a key variable for the project. | A change of approximately 15 % in the price variable is necessary before the NPV becomes zero or before the IRR equals the cut-off rate. |
| Characteristic | Indicates to which variables the project result is or is not sensitive. Suggests further examination of change in variable. | Measures extent of change for a variable which will leave the project decision unchanged. |

The switching value is، by definition، the reciprocal of the sensitivity indicator. Sensitivity indicators and switching values calculated towards the IRR yield slightly different results if compared to SIs and SVs calculated towards the NPV. This is because the IRR approach discounts all future net benefits at the IRR value and the NPV approach at the discount rated.

### 6.2.3 Step 4: Analysis of Effects of Changes in Key Variables

In the case of an increase in investment costs of 20 percent، the sensitivity indicator is 13.34. This means that the change of 20 percent in the variable (investment cost) results in a change of (13.3 x 20 percent) = 266 percent in the ENPV. It follows that the higher the SI، the more sensitive the NPV is to the change in the concerned variable.

In the same example، the switching value is 7.5 percent which is the reciprocal value of the SI x 100. This means that a change (increase) of 7.5 percent in the key variable (investment cost) will cause the ENPV to become zero. The lower the SV، the more sensitive the NPV is to the change in the variable concerned and the higher the risk with the project.

### 6.2.4 Limitation of Sensitivity Analysis

The main limitation of the use of sensitivity analysis for risk appraisal of an investment project is that it does not allow changes of more than one parameter at the same time.

## 7. Conclusions

The investment appraisal is concerned with how to identify، analyze، and interpret the expected variability in project outcomes; it enhances decision-making on marginal projects. A project whose single-value NPV is small may still be accepted following risk analysis as shown previously ، on the grounds that its overall chances for yielding satisfactory return are greater than is the probability of making an unacceptable loss. Likewise، a marginally positive project could be rejected on the basis of being excessively risky، or one with a lower NPV may be preferred to another with a higher NPV because of a better risk/return profile. Overlooking significant inter-relationships among the projected variables can distort the results of risk analysis and may lead to misleading conclusions. Risk analysis amplifies the predictive ability of sound models of reality. The accuracy of its prediction can only be as good as the predictive capacity of the model employed.

So risk is an essential component in decision-making in all businesses but is even more important in agriculture because of the exposure to institutional and production risk. Information from deterministic projections based on the assumption of point estimates of uncertain variables may not tell the full story for the purpose of developing future planting decisions since the probability distributions of certain outcomes are not considered.

Another relevant aspect of the same problem of creating the profit and enabling the agricultural enterprise growth. In that sense، they must be better educated. So، in the paper the methods of risk analysis are discussed to help the managers and owners of the firm for its better management and better decision making. In that process، one can identify the level of riskiness but also the certainty and possibility of creating the cash flow in the agricultural enterprise. It was the main task of the paper.

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