MEASUREMENT AND MANAGEMENT OF RISK AND UNCERTAINTY IN AGRICULTURE

Department of Agricultural economics, Extension education & Rural Sociology

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FLOW OF PRESENTATION

1. Introduction
2. Objectives
3. Previous Findings
4. Methodology
5. Discussion
6. Conclusion & Policy Implication
Introduction

- Agricultural production is subject to many risks uncertainties. Any farm production decision plan is typically associated with multiple potential outcomes with different probabilities.

- Weather, market developments and other events cannot be controlled by the farmer but have a direct incidence on the returns from farming. In this context, the farmer has to manage risk in farming as part of the general management of the farming business.
An Overview of Vulnerability of Risks and Uncertainty in Agriculture

In developing countries the agriculture sector absorbs about 22 percent of the total damage and losses caused by natural hazards.
Disasters jeopardize agricultural production and development and often have cascading negative effects across national economies.
The number of climate-induced disasters has increased significantly over the last decade.

Of all natural hazards, floods, droughts and tropical storms affect the agriculture sector most showing the severe impact of climate-related disasters.

More than 80 percent of the damage and losses caused by drought is to agriculture, especially livestock and crop production.

The fisheries subsector is most affected by tsunamis and storms, while most of the economic impact on forestry is caused by floods and storms.
Indirect losses experienced by the agriculture sector in the seasons after a disaster are twice as high as the direct damage to agricultural assets.

Almost three-quarters of recorded post-disaster damage and losses to agriculture were to the crops and livestock subsectors.

Twenty-five percent of the economic impact caused by climate-related disasters falls on the agriculture sector.
Global trends in damage and losses to the agriculture sector

In terms of direct physical damage alone, **roughly 14% was to the agriculture sector** while the remaining damage was to other sectors. This direct damage to agriculture typically includes the partial or total destruction of vital agricultural infrastructure and assets, including standing crops; farm tools and equipment; irrigation systems; livestock shelters and veterinary services; fishing boats and equipment; landing sites; aquaculture equipment and hatcheries; storage, processing, marketing and transport facilities; buildings and equipment of farm schools and cooperatives, and sector ministries and their departments.

Nearly 30% of the share of losses was to the agriculture sector alone. The greatest economic impact of disasters to the agriculture sector stems from losses, while the physical damage is smaller given the relatively lower monetary value of agricultural assets when compared with infrastructure such as housing or roads. The losses to the agriculture sector include a decline in crops, livestock and fisheries and aquaculture production; increased cost of production, lower revenues and higher operational costs for services; unexpected expenditures to meet humanitarian and recovery needs in the sector.
Crop and livestock production losses after disasters over the past decade

USD 48 billion in crop and livestock losses 2003–2013

2% of the projected value of production

Floods were associated with 77% of the region’s losses. While the region experienced the largest absolute production losses, it was least affected in relation to the projected value of production. India was most affected by losses after recurrent floods from 2004 to 2013, while the Philippines (e.g., 2012 Bopha and 2013 Haiyan Typhoons), Pakistan (e.g., 2010 floods), Cambodia (e.g., 2005 drought) and Thailand (e.g., 2008 drought) were also hard-hit.

Source: FAO, based on FAOSTAT

Legend: Storms, Floods, Drought, Earthquakes
Some 90% of the region's losses occurred after *droughts*, when most countries experienced sharp declines in yields, likely leading to losses in output and revenue. Droughts severely challenge food availability, rural livelihoods and overall economies, particularly given agriculture's critical contribution to food security and economies in sub-Saharan Africa.

Source: FAO, based on FAOSTAT
LATIN AMERICA AND THE CARIBBEAN

USD 11 billion in crop and livestock losses 2003–2013

3% of the projected value of production

Most losses occurred after floods (55%) followed by droughts and storms. Brazil was most affected, also due to the large size of its agricultural production, following 2009 floods in the north of the country. Other seriously affected countries included Colombia (2007, 2010 and 2011 floods), Mexico (2005 Hurricane Emily, 2007 Tabasco floods and 2011 drought) and Paraguay (2011–12 drought)

Source: FAO, based on FAOSTAT

Legend: Storms, Floods, Drought, Earthquakes
The Near East was the most affected region in relative terms, with most losses occurring after the 2008 drought in Syria.
Damage and losses to the agriculture in India

Source: FAO based on data from post-disaster needs assessments, 2003–2013
Many risks directly affect farmer’s production decisions and welfare. In response to the potential impact of these uncertain events farmers implement diverse risk management strategies in the context of their production plans, the available portfolio of financial, physical and human capital, and the degree of aversion to risk.

These risk management strategies may include decisions on-farm, changes in portfolio structure, use of market instruments, government programs, and diversification to other source of income.

Many general agricultural support policies have risk management implications and influence risk management decisions. Because of the complexity of these interactions governments need to make significant efforts to achieve coherence, particularly among different policies and between policies and market strategies.
Agricultural risk is an interrelated system in which markets and government actions interact with risks and farmers’ strategies. Government programs may underpin the development of market strategies, but they may also crowd out market developments or on-farm strategies.

The result of these interactions is the set of risk management strategies and tools that is available and used by farmers. The available strategies are not the simple addition of government programs, market instruments and on-farm decisions; they are mutually interdependent and constitute a unique system.

With this view the topic is going to discuss under the following objectives:
Objectives

1. To understand the types of risk and uncertainty in agriculture

2. To illustrate risk management strategies in agriculture

3. To understand the different measurement and decision criteria under risk and uncertainty in agriculture
# Previous Findings

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Events are uncertain when their outcome alter a decision maker’s material or social well-being.</td>
</tr>
<tr>
<td>2.</td>
<td>Uncertainty as imperfect knowledge and risk as uncertain consequences.</td>
</tr>
<tr>
<td>3.</td>
<td>Risk is uncertainty that affect a person’s welfare. Uncertainty is necessary for risk to occur, but uncertainty need not lead to a risky situation.</td>
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<tr>
<td>4.</td>
<td>The agricultural producers face two types of risks. One is the risk of loss of production due to unfavorable weather and soil conditions and the other is the risk on account of depressed prices.</td>
</tr>
</tbody>
</table>
After reviewing the available literature related to the present topic, a systematic procedure was adopted for the detailed study of the topic.

The study is mainly based on the secondary sources that were obtained from different journals, books, internet etc.
Discussion
1. To study the types and sources of risk and uncertainty in agriculture
“Risk is measurable uncertainty”

“Uncertainty is unmeasurable risk”
## Risk Vs Uncertainty

<table>
<thead>
<tr>
<th>BASIS FOR COMPARISON</th>
<th>RISK</th>
<th>UNCERTAINTY</th>
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</thead>
<tbody>
<tr>
<td>Meaning</td>
<td>The probability of winning or losing something worthy is known as risk.</td>
<td>Uncertainty implies a situation where the future events are not known.</td>
</tr>
<tr>
<td>Ascertainment</td>
<td>It can be measured</td>
<td>It cannot be measured.</td>
</tr>
<tr>
<td>Outcome</td>
<td>Chances of outcomes are known.</td>
<td>The outcome is unknown.</td>
</tr>
<tr>
<td>Control</td>
<td>Controllable</td>
<td>Uncontrollable</td>
</tr>
<tr>
<td>Minimization</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Probabilities</td>
<td>Assigned</td>
<td>Not assigned</td>
</tr>
</tbody>
</table>
## Sources of Risk in Agriculture

- Production Risk
- Price or Market Risk
- Financial and Credit Risk
- Institutional Risk
- Human or Personal Risk
- Legal / Policy Risk
- Resource Risk
- Health Risks
- Assets Risks
- Technology Risk
**PRODUCTION RISK**

Agriculture is often characterized by high variability of production outcomes or production risk.

Unlike most other entrepreneurs, farmers are not able to predict with certainty the amount of output that the production process will yield due to external factors such as weather, pests, and diseases.

Farmers can also be hindered by adverse events during harvesting or threshing that may result in production losses. Development and adoption of innovations also add to production risk in agriculture.

In India, more than 60 percent of land is vulnerable to droughts. Droughts lead to economic losses resulting from low agricultural production, loss of animal wealth, reduced nutrition and loss of health of workers.
PRICE OR MARKET RISK

- Price or market risk refers to uncertainty about the prices producers will receive for commodities or the prices they must pay for inputs.

- The nature of price risk varies significantly from commodity to commodity.

- The market risks result from fluctuations in the prices of inputs and outputs, outside competition, changing supply and demand, market imperfections, changing consumer preferences, etc.

- Sale of farm produce under distress may take place due to lack of post harvest processing and lack of infrastructure storage facilities.
Many agricultural production cycles stretch over long periods of time, and farmers must anticipate expenses that they will only be able to recupereate once the product is marketed.

This leads to potential cash flow problems exacerbated by lack of access to insurance services, credit and the high cost of borrowing.

This also creates an obligation to repay debt. Rising interest rates, the prospect of loans being called by lenders, and restricted credit availability to the farmers lead to financial risks.
Important source of uncertainty for farmers is institutional risk, generated by unexpected changes in regulations that influence farmers' activities.

Changes in regulations, financial services, level of price or income support payments and subsidies can significantly alter the profitability of farming activities.
HUMAN OR PERSONAL RISK

- This risk refers to factors such as problems with human health or personal relationships that can affect the agriculture.

- Agricultural households, as any other economic entrepreneur, are exposed to personal risks affecting the life and the wellbeing of people who work on the farm, as also asset risks from floods, cyclones and droughts and possible damage or theft of production equipment and any other farming assets.
LEGAL / POLICY RISK

- The legal and policy risk arises due to changes in the government policies related to agriculture, failure to comply with contractual obligations, etc.

RESOURCE RISK

- The resource risks include uncertain supply or non-availability of labor (skilled labor), credit and irrigation water and also timely supply of desired seed, fertilizer or plant protection chemicals. Supply of spurious seeds and plant protection chemicals pose a great risk to the producers.

- Failure of crops due to sub-standard seed or spurious plant protection chemicals causes drain of resources of the farmer.

- It inflicts considerable damage on the psyche of the farmer sometimes leading to suicides by the farmers.
HEALTH RISKS

- The health risk arises due to sickness or injury to the farmer, low labor productivity due to poor labor management, family disputes, accidental death, etc.

- Agriculture is a hazardous occupation. The International Labor Organization (ILO) estimates that among the world's 2.7 billion workers, at least 2 million deaths per year are attributable to occupational diseases and injuries.
<table>
<thead>
<tr>
<th>ASSETS RISKS</th>
<th>TECHNOLOGY RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ The trade-off is most acute for small farmers because their opportunities</td>
<td>▪ Like most other entrepreneurs, farmers are responsible for all the consequences</td>
</tr>
<tr>
<td>for ex-post management of risk through credit are limited.</td>
<td>of their activities.</td>
</tr>
<tr>
<td>▪ When all other measures fail, farmers have no option but to sell their</td>
<td>▪ Adoption of new technologies in modernizing agriculture such as in introduction</td>
</tr>
<tr>
<td>assets (principally livestock) or to migrate out to regions with better</td>
<td>of genetically modified crops causes an increase in producer liability risk.</td>
</tr>
<tr>
<td>work opportunities.</td>
<td></td>
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</tbody>
</table>
UNCERTAINTY IN AGRICULTURE

- **Price uncertainty:** Prices of products / inputs are not known to the farmers with certainty

- **Yield uncertainty:** Farmers may not be able to predict the yield of crops with certainty because of weather conditions, incidence of pests and disease, etc.

- **Technological uncertainty:** farmers may not be aware of the exact impact of new technology on the quantity and quality of yield.

- **Institutional uncertainty:** Conditions of tenure, functioning of credit agencies are examples for institutional uncertainties.
2. To illustrate risk management strategies in agriculture
RISK MANAGEMENT STRATEGIES

- In order to cope with various risks, farmers and rural societies have developed number of risk management strategies.

- These can be grouped as risk-reducing and risk-coping strategies (Walker and Jodha 1986).

- The ex-ante measures adopted to lower or minimize risks can be grouped as risk-reducing strategies whereas ex-post measures adopted to mitigate risks are classified as risk-coping measures or strategies.
# EX-ANTE RISK MANAGEMENT STRATEGIES IN AGRICULTURE

<table>
<thead>
<tr>
<th>Informal Mechanisms</th>
<th>Formal Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-farm</strong></td>
<td></td>
</tr>
<tr>
<td>· Avoiding exposure to risk</td>
<td>· Agricultural extension</td>
</tr>
<tr>
<td>· Crop diversification and inter-cropping</td>
<td>· Supply of quality seeds, inputs, etc</td>
</tr>
<tr>
<td>· Plot diversification</td>
<td>· Pest management systems</td>
</tr>
<tr>
<td>· Mixed farming</td>
<td>· Infrastructures (roads, dams, irrigation)</td>
</tr>
<tr>
<td>· Diversification of income source</td>
<td></td>
</tr>
<tr>
<td>· Buffer stock accumulation of crops or liquid assets</td>
<td></td>
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<tr>
<td>· Adoption of advanced cropping techniques (fertilization, irrigation, resistant varieties)</td>
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<td></td>
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<tr>
<td><strong>Sharing risk with others</strong></td>
<td></td>
</tr>
<tr>
<td>· Crop sharing</td>
<td>· Contract marketing</td>
</tr>
<tr>
<td>· Sharing of agricultural equipment, irrigation sources, etc</td>
<td>· futures contracts</td>
</tr>
<tr>
<td>· Informal risk pool</td>
<td>· Insurance</td>
</tr>
<tr>
<td>· Contract marketing</td>
<td></td>
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<tr>
<td>· futures contracts</td>
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</table>
### EX-POST RISK MANAGEMENT STRATEGIES IN AGRICULTURE

<table>
<thead>
<tr>
<th>Informal Mechanisms</th>
<th>Formal Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coping with shocks</strong></td>
<td><strong>Market based</strong></td>
</tr>
<tr>
<td>· Reduced consumption patterns</td>
<td>· Credit</td>
</tr>
<tr>
<td>· Deferred / low key social &amp; family functions</td>
<td></td>
</tr>
<tr>
<td>· Sale of assets</td>
<td></td>
</tr>
<tr>
<td>· Migration</td>
<td></td>
</tr>
<tr>
<td>· Reallocation of labor</td>
<td></td>
</tr>
<tr>
<td>· Mutual aid</td>
<td></td>
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</tbody>
</table>

**Source:** *Report of The Working Group on Risk Management in Agriculture, 2007-2012*
Risk-reducing strategies adopted by farmers include crop diversification, inter-cropping / mix cropping, or cultivation of drought or flood resistant crops.

Diversification of activities, engaging in nonfarm/ off-farm activities, getting into contractual arrangements such as share cropping, labor hiring, etc. also form a part of ex-ante risk mitigating strategies.
Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities.

- Crop diversification is the most common and effective risk management strategy that is employed by the farmers.

- The farmer spreads risk across multiple crops and even if one crop fails, it is compensated by another crop.

- However, crop diversification leads to spreading of limited resources across crops and the price paid for diversification is income foregone or sacrificed by not growing the most remunerative crop.
INTERCROPPING

- Intercropping lowers yield risks because of lower incidence of insect/pest damage as well as disease.
- Intercropping has greater potential for yield compensation.
- It also provides opportunity to grow short duration crops along with long duration crops thus minimizing competition for soil nutrients and maximising the use of soil moisture, sunlight, etc.
- Even though intercropping is not found effective in reducing production risk as shown by positive covariance between the yields of inter crops (Walker and Jodha 1986), it certainly helps in avoiding complete crop failure (Singh and Walker 1984).
TENANCY OR SHARE-CROPPING

- Tenancy or share-cropping helps to minimize risk in production.

- Share cropping is more beneficial particularly when the tenant is a small farmer and averse to risk, as the tenant has to share a fraction of output to the land owner and he is insulated against the fluctuations in output.

- The risk-reducing strategy stabilizes farm income but at the same time the farmer has to forego income from other alternative activity, which would have fetched higher income.

**SHARECROPPING**

**Advantages**
- Part of a business venture
- Raised their social status
- Received 1/3 to 1/2 of crop when harvested
- Raised their self esteem

**Disadvantages**
- Some landowners refused to honor the contract
- Blacks poor and in debt
- Economic slavery
The theory of share tenancy was long dominated by Alfred Marshall’s famous footnote in Book *Principles of Economics* where he illustrated the inefficiency of agricultural share-contracting.

Steven N.S. Cheung (1969), challenged this view, showing that with sufficient competition share tenancy will be equivalent to competitive labor markets and therefore efficient.

He also showed that share-contracting may be preferred to either wage contracts or rent contracts—due to the mitigation of labor shirking and the provision of risk sharing.

Joseph Stiglitz (1974), suggested that if share tenancy is only a labor contract, then it is only pairwise-efficient and that land-to-the-tiller reform would improve social efficiency by removing the necessity for labor contracts in the first place.
RISK-COPING STRATEGIES (*ex-post*)

- Farm families adopt different strategies to adjust the shortfall in income.

- The ex-post measures taken to mitigate the impact of income losses include self insurance, sale of assets, stored produce, and receipt of transfers from relatives, borrowals for consumption, increase labor participation and even migration for better employment opportunities.
SELF INSURANCE

- This is the most important mechanism for consumption smoothing other than market credit and interfamily lending, sale and purchase of assets.

- Agricultural households hold many different forms of wealth including land, capital goods such as pump sets and tractors, animals, jewellery, currency and stocks of food grains.

- Self insurance relates to using such assets as buffer stocks. Farmers accumulate stocks in period of relative affluence and deplete these reserves to finance consumption expenditures during tough times.
AGRICULTURAL CREDIT

- The second major form of smoothing consumption is taking loans from formal and informal sources.

- Farmers approach formal or institutional lenders like Government banks, co-operative societies, commercial banks, credit bureaus as well as informal lenders like money lenders, traders, friends and relatives for taking credit.

Union Budget 2017

- Target for agricultural credit in 2017-18 has been fixed at a record level of 10 lakh crores.

- To ensure flow of credit to small farmers, Government to support NABARD for computerization and integration of all 63,000 functional Primary Agriculture Credit Societies with the Core Banking System of District Central Cooperative Banks. This will be done in 3 years at an estimated cost of `1,900 crores.
CONTRACT FARMING

- Contract farming is a contractual arrangement between farmers and the processor, whether oral or written, specifying one or more conditions of production and/or marketing of an agricultural produce.

- Based on the nature of risk sharing and contract specifications. They can be classified into 3 broad categories.
(1) Market specification contract
- The contract is a pre-harvest
- Specific to price, quality and timing of delivery of the produce.
- These types of contracts are common in the case of orchards.

(2) Resource providing contract
The contracting firms supplies production inputs, extension and credit, in exchange for a marketing arrangement.

(3) Management and income guaranteeing contract
- The production and marketing stipulations, of the former two types.
- In addition, market and price risks are transferred from the farmer to the firm, and the farmer is assured of a certain level of revenue.
- However, the contracting firms, take a substantial part of the managerial responsibility of the farmer. These types of contracts are common in the case of the poultry industry.
LABOUR MARKETS

- Labor markets provide alternative mechanism to deal with risk by allowing households subject to idiosyncratic income shocks to shift from own-farm cultivation to the labor market and to avoid uncertainties of the slack season.

- Many landless workers enter permanent labor contracts to avoid seasonal fluctuations in wages and employment opportunities.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Agriculture</td>
<td>47%</td>
</tr>
<tr>
<td>Industry</td>
<td>22%</td>
</tr>
<tr>
<td>Services</td>
<td>31%</td>
</tr>
</tbody>
</table>
3. To study the different decision criteria under risk and uncertainty in agriculture

- Some decision criteria for uncertainty
  I. Maximin Criterion
  II. Minimax Regret Criterion
  III. Hurwicz Criterion
  IV. Laplace Criterion
Several criteria which have received considerable attention in the literature on decision problems under uncertainty are the game theoretic algorithms. These criteria have been proposed for a wide variety of decision problems in economics and agricultural economics.

The types of problems for which they can be used can be grouped into two-person zero-sum games and other games, including n-person games.

The two-person games can be classified into games in which both players are conscious adversaries and games against Nature in which Nature plays a passive role.
**Maximin Criterion**

The maximin criterion selects that act with the maximum minimum gain, i.e. $\text{Max}_j(\text{min}_i u_{ij})$.

Conventionally, statistician have framed decision problems in terms of losses hence the criterion is better known as the minimax or Wald criterion.

**Minimax Regret (Savage) Criterion**

The act with the smallest maximum regret, $R_{ij}$, is selected. The regret is determined by subtracting each payoff $u_{ij}$ from the maximum possible payoff for that event ($\text{max}_i u_{ij}$). That is $R_{ij} = (\text{max}_i u_{ij}) - u_{ij}$

Where $R_{ij}$ is the regret for the $J^{th}$ act and $i^{th}$ event. Thus the algorithm becomes $\text{min}_i(\text{max} R_{ij})$. 
Maximin Criterion

Payoff Table

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Growing</th>
<th>Stable</th>
<th>Declining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonds</td>
<td>40</td>
<td>45</td>
<td>5</td>
</tr>
<tr>
<td>Stocks</td>
<td>70</td>
<td>30</td>
<td>-13</td>
</tr>
<tr>
<td>Mutual Funds</td>
<td>53</td>
<td>45</td>
<td>-5</td>
</tr>
</tbody>
</table>

Best

<table>
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<tr>
<th>Alternatives</th>
<th>Growing</th>
<th>Stable</th>
<th>Declining</th>
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<tbody>
<tr>
<td></td>
<td>45</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>70</td>
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<td></td>
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<tr>
<td></td>
<td>53</td>
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</table>

Decision: Invest in **Stocks**

Minimax Regret (Savage) Criterion

Regret Table

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Growing</th>
<th>Stable</th>
<th>Declining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonds</td>
<td>30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stocks</td>
<td>0</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Mutual Funds</td>
<td>17</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

Maximum

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Growing</th>
<th>Stable</th>
<th>Declining</th>
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<td>17</td>
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</table>

Decision: Invest in **Mutual Funds**
Hurwicz Criterion

- The Hurwicz criterion takes the best and worst outcomes of each act and weights these in an index according to the pessimism (or optimism) of the decision maker. The act with the largest index is selected. The coefficient of pessimism $\alpha$ is estimated from a single-person game with actions $a_1$ and $a_2$ and two states of Nature $s_1$ and $s_2$ whose probabilities of occurrence are unknown. For example from the game

<table>
<thead>
<tr>
<th></th>
<th>$a_1$</th>
<th>$a_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_1$</td>
<td>1</td>
<td>$\times$</td>
</tr>
<tr>
<td>$s_2$</td>
<td>0</td>
<td>$\times$</td>
</tr>
</tbody>
</table>

- $\times$ is determined so that the decision maker is indifferent between acts $a_1$ and $a_2$. Then the $\alpha$ is determined by making use of the fact that indifference implies

$$\alpha 0 + (1 - \alpha) 1 = \alpha \times + (1 - \alpha) \times,$$

So that $\alpha = 1 - \times$. 
# Hurwicz Criterion

<table>
<thead>
<tr>
<th>Alternatives</th>
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</tr>
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<td>45</td>
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<td>70</td>
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</tr>
<tr>
<td>Mutual Funds</td>
<td>53</td>
<td>45</td>
<td>-5</td>
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<table>
<thead>
<tr>
<th>Weighted Average</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonds</td>
<td>$0.3(45) + 0.7(5) = 17.0$</td>
</tr>
<tr>
<td>Stocks</td>
<td>$0.3(70) + 0.7(-13) = 11.9$</td>
</tr>
<tr>
<td>Mutual Funds</td>
<td>$0.3(53) + 0.7(-5) = 12.4$</td>
</tr>
</tbody>
</table>

**Decision:** Invest in **Bonds**
Laplace Criterion

- When the state of nature is one of uncertainty all the possible events are given equal weightage. The act with the maximum expected gain is selected; i.e., the act for which

\[ \max_j \left( \sum_i u_{ij}/m \right) \]

Laplace (The criterion of equal probabilities)

<table>
<thead>
<tr>
<th>Alternative/State of Nature</th>
<th>s1</th>
<th>s2</th>
<th>s3</th>
<th>s4</th>
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• Some decision criteria for Risk

I. Expected Profit Maximization
   (a.) Quadratic Programming
   (b.) Minimization of Total Absolute Deviation (MOTAD) Model

II. Expected Utility Maximization
I. Expected Profit Maximization

- It has observed that, for a competitive firm under price uncertainty, expected profit maximization is in general inconsistent. Expected profit maximization is consistent if and only if there is no possibility of negative profit, or equivalently, loss.

(a.) Quadratic Programming

Quadratic Programming (QP) tackles the problems of random variations in enterprise outputs as caused by annual fluctuations in yield and prices. It provides the maximum profit at any given level of income variation or risk. Thus, in QP the farmer can take into account not only the average profit but also the minimum profit (or maximum loss) that is likely to occur in bad years.
I. Expected Profit Maximization

(b.) Minimization of Total Absolute Deviation (MOTAD) Model

Hazzel (1971) developed MOTAD model as a linear iterative quadratic programming for farm planning under risk. This model uses linear decision criterion with expected returns and mean absolute deviations.

He observed that the MOTAD model could be solved with conventional linear programming packages. Risk is incorporated in the model as mean absolute deviation of farm profit.
II. Expected Utility Maximization

In economics, the expected utility hypothesis (game theory and decision theory), concerning people's preferences with regard to choices that have uncertain outcomes (gambles), states that if specific axioms are satisfied, the subjective value associated with an individual's gamble is the statistical expectation of that individual's valuations of the outcomes of that gamble.

Initiated by Daniel Bernoulli in 1738, this hypothesis has proved useful to explain some popular choices that seem to contradict the expected value criterion (which takes into account only the sizes of the payouts and the probabilities of occurrence), such as occur in the contexts of gambling and insurance.

The von Neumann–Morgenstern utility theorem provides necessary and sufficient conditions under which the expected utility hypothesis holds. From relatively early on, it was accepted that some of these conditions would be violated by real decision-makers in practice but that the conditions could be interpreted nonetheless as 'axioms' of rational choice.
Conclusion

- The agricultural risks are exacerbated by a variety of factors, ranging from weather variability, frequent natural disasters, uncertainties in yields and prices, weak rural infrastructure, imperfect markets and inadequate and sub-optimal financial services.

- These factors not only endanger the livelihood and incomes of small farmers but also undermine the viability of the agriculture sector and its potential to become a part of the solution to the problem of the endemic poverty of farmers.

- Agriculture is a dominant sector of our economy and credit plays an important role in increasing agriculture production. Availability and access to adequate, timely and low cost credit from institutional sources is of great importance especially to small and marginal farmers.

- Along with other inputs, credit is essential for establishing sustainable and profitable farming systems. Most of the farmers are small producers engaged in agricultural activities in areas of widely varying potential.
Policy Implications

- Transition of the Crop Insurance Scheme should be made to an actuarial regime supported by upfront subsidy in premium with insurers taking full responsibility for claims, save catastrophe claims.

- Strengthening the weather insurance system through technological developments like electronic weather stations and remote sensing technology.

- Contract farming should be popularized as an alternative risk management instrument.

- To introduce farm income insurance scheme to protect farmers’ incomes more comprehensively.

- To introduce price stabilization fund and credit risks management fund to insulate farmers from price volatility.
Thank you for listening