Session 8:
Deep dive into Area Yield Index Insurance (AYII)

5-8 March 2024
Muldersdrift, South Africa

DRF for Agriculture and Climate Resilient Livelihoods

Disaster Risk Financing & Insurance Program

Supported by World Bank Group

Eswatini  Namibia  Uganda
Ethiopia  Rwanda  Zambia
Kenya  Somalia  Zimbabwe
Lesotho  South Africa
By the end of this session, you should understand more about:

- What is AYII and how does it work
- What are AYII advantages and disadvantages compared to other crop insurance products
- What are implementation and design considerations for governments
- How does an AYII scheme work in Kenya
Global landscape of crop insurance

Global presence of crop indemnity insurance

Key Takeaways

- Agricultural insurance premiums nearly doubled between 2008 and 2017 and has continued to rise.
- Emerging markets the crop protection gap is USD 88 billion Vs. USD 25 billion in advanced markets
- Globally MPCI is largest class by premium volume of all types of agricultural insurance

Sources: Stutley, DRF for agriculture, 2021; Swiss Re Sigma, 2023; Author
But crop index insurance quadrupled between 2009 to 2019

Sources: Stutley, DRF for agriculture, 2021; Swiss Re Sigma, 2023; Author

What % does Africa contribute to of global agricultural insurance premiums?
Crop insurance in Sub-Saharan Africa

Presence of crop insurance in SSA by type of product (Indemnity, WII, AYII)

**KEY TAKEAWAYS**

- 30 countries have crop insurance today (including micro, meso, and macro) vs. only 6 in 2008
- 86 crop insurance schemes
- Most number of schemes are index insurance: 53 WII, 24 AYII
- South Africa largest premium volume: large crop-hail market and MPCI for commercial farmers
- 6 countries have the highest penetration of index insurance: Kenya, Nigeria, Rwanda, Senegal, Uganda, Zambia
Area Yield Index Insurance
What and Why?
What is AYII?

Comprehensive risk coverage, scalable for smallholders

Purpose and Function

Not for individual farm losses. AYII acts as yield shortfall guarantee at the area level:

- Payouts made if average yield in an area is enough below the expected/normal average yield & specified by trigger level in the index design

Key components

- Covers multiple natural risks that affects the crop production and yield in a defined insured area (UAI)
- Reduces moral hazard: farmers cannot influence payout
- Reduces adverse selection: farmers cannot influence yield outcome in a whole UAI

Preconditions

- Homogenous cropped areas with: low yield variation between farms; common farming practices & agroclimatic conditions
- Historical data for insured areas: crop sown area, production and average yield data, ideally for the past 15 years+
- Low cost, timely, accurate system to estimate the actual average yield in the UAI at the time of harvest and that is acceptable to farmers, insurers and their reinsurers.
AYII provides payouts when the yield of an area falls below a predetermined % of the ‘normal average’ or expected yield.

Area yield index insurance is a type of insurance which pays farmers with respect to the normal average or expected yield in the area.

Example shows: Insured Yield set at 80% of the Expected Yield (or normal average area yield).

Graph:
- **‘Normal average’ or ‘expected’ yield**
- **Coverage level at 80% of average yield**
- **Yield shortfall to be compensated by insurance payout**

Crop season without payout vs Crop season with payout.
AYII is lower cost than MPCI and with less basis risk than WII

<table>
<thead>
<tr>
<th>Multi-peril crop insurance</th>
<th>Traditional indemnity insurance product against all perils.</th>
<th>Payouts are determined through a farm-level loss assessment process</th>
<th>Red</th>
<th>Red</th>
<th>Green</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm</td>
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<tr>
<td>Area-yield index insurance</td>
<td>AYII is based on average losses at an area level, rather than farm level</td>
<td>It is most often based on crop-cutting experiments (CCEs)</td>
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<td>Village</td>
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<tr>
<td>Weather index insurance</td>
<td>Based on weather parameters (such as rainfall, temperature, or soil moisture) correlated with crop loss</td>
<td>Typically covers single, weather-related peril</td>
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<tr>
<td>Village</td>
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<table>
<thead>
<tr>
<th>Transaction costs</th>
<th>Moral hazard &amp; adverse selection</th>
<th>Basis risk</th>
<th>Claims settlement time</th>
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<tbody>
<tr>
<td>Red</td>
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<td>Green</td>
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### Why AYII compared to WII?

**One size does not fit all: consider risks, crops, purpose**

<table>
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<th>Value chain suitability</th>
<th><strong>AYII</strong></th>
<th><strong>WII</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Row crops: E.g. Cereals, legumes, cotton.</td>
<td>Typically 1 at End of Season</td>
<td>Also applicable for horticulture, tree, plantation and temperate crops; and for pasture in IBLI products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Claims payout frequency</th>
<th><strong>AYII</strong></th>
<th><strong>WII</strong></th>
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</thead>
<tbody>
<tr>
<td>Most applications have been for micro, but meso and macro level is possible. Linked to agricultural production risks</td>
<td>Has been applied for micro, meso, macro. Not always linked to agricultural production risks</td>
<td></td>
</tr>
</tbody>
</table>

**Level & purpose**

Why did you choose AYII or WII?
Area Yield Index Insurance: How? Implementation Considerations
Defining the right Unit Areas of Insurance (UAIs) underpins design & implementation

UAI = predefined area in which all fields are grouped and all farmers receive same policy and payouts.

CCEs need to be conducted each season in a sample of fields in every UAI (5-15 CCEs typically taken per UAI).

**UAIs for AYII principles:**

- Group fields with homogeneous agroclimatic conditions, farming practices, crop yields, & exposure to production risks **to minimize basis risk**

- Follow aggregation of administration units as much as possible to aid implementation

- Some variability acceptable between farm yields within a UAI. But yields should vary in the same direction and in similar proportions.

**Picking the right size. What are the trade offs between big UAIs Vs small UAIs?**

Map: Kithimu Ward, Embu County, Kenya
Divided into 2 UAIs at ward level
Crop Cutting Experiments (CCEs) and Unit Areas of Insurance (UAIs)

**India PMFBY AYII experience**
Since 1980. Based on state-governed CCE system. Carried out by extension officers (Indian equivalent)

**Operational challenges:**
- **CCE numbers required:** 4 CCEs per village for all major crops and 8 CCEs for minor crops
- **Increased total annual number of CCEs required in the whole country:** from c. 2-3 million to about 6-8 million.
- **Short time-frame to conduct CCEs**
- **Extension officer overburdened with multiple activities**
- **Insurance company agents and district agricultural dept. officials are supposed to be present to ensure integrity of CCEs, but in reality doesn’t happen**

**Spatial basis risk** → reduced UAI size from the sub-district level (block of 6-8 villages) to individual village level.

**Impact:**
- **CCEs quality deteriorated** and **major delays** in finalizing CCEs and settling claims payouts:
  - CCE numbers required: 4 CCEs per village for all major crops and 8 CCEs for minor crops
  - **Increased total annual number of CCEs required in the whole country from c. 2-3 million to about 6-8 million.**
  - Short time-frame to conduct CCEs
  - Extension officer overburdened with multiple activities
  - Insurance company agents and district agricultural dept. officials are supposed to be present to ensure integrity of CCEs, but in reality doesn’t happen

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**Too big UAIs:**
higher basis risk

**Too small UAIs:**
higher operational costs
Crop Cutting Experiments (CCEs): what and how?

Key steps for estimating the average yield of an area through CCEs:

1. Randomly sample a predetermined number of farms in a Unit Area of Insurance
2. Locate random sampled plots in fields of selected farms
3. Mark out sub-plots and harvest the crop yield
4. Weigh the harvested sub-plots’ crop
5. Process the data to establish the average yield of the local area (UAI) to determine payouts

No fixed rules on size and shape of CCE

To be determined type of crop & planting pattern

<table>
<thead>
<tr>
<th>Cereals</th>
<th>Roots Tubers etc.</th>
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</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
<td><strong>Plot Size</strong></td>
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<tr>
<td>Maize</td>
<td>6m X 6m</td>
</tr>
<tr>
<td>Rice</td>
<td>3m X 3m</td>
</tr>
<tr>
<td>Millet</td>
<td>6m X 6m'</td>
</tr>
<tr>
<td>Guinea Corn</td>
<td>6m X 6m'</td>
</tr>
<tr>
<td>Cassava</td>
<td>4.5m X 4.5m</td>
</tr>
<tr>
<td>Yam</td>
<td>9m x 9m</td>
</tr>
<tr>
<td>Cocoyam</td>
<td>4.5m X 4.5m</td>
</tr>
<tr>
<td>Plantain</td>
<td>9m x 9m</td>
</tr>
</tbody>
</table>

Table shows Ghana MoA plot sizes per crop
# Crop Cutting Experiments (CCEs). Implementation considerations

## Decision points

<table>
<thead>
<tr>
<th>Plot size</th>
<th>Larger Vs smaller size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farms/Fields per crop (in UAI)</td>
<td>5-15 CCEs typically taken per UAI</td>
</tr>
<tr>
<td>Samples per field</td>
<td>1 to 2 (e.g. India, Pakistan, Kenya)</td>
</tr>
</tbody>
</table>
| Number of visits Vs investment in equipment | Weighing wet and dry yield: 2 field visits, 10 to 15 days to estimate dry yield
Funding grain moisture metres:
- CCE yield is calculated in 1 visit
- Major cost savings in staff time
- Results can be provided up to 15 days earlier |

### Accuracy Vs time and cost
Who carries out CCEs? Pros & cons

**Government conducted CCEs**
- Government owns data
- Data can be useful beyond insurance
- Existing government staff and systems can be used
- Can build on existing government stats. In Africa very few governments have historical CCE record but many have historical production and crop yield data
- Government pays directly for CCE system: requires high investment and continued monitoring

E.g. India PMFBY, Kenya, Rwanda

**Private Technical Service Provider or NGO conducted CCEs**
- Can create efficiencies
- Can spur new solutions
- Can be used for other schemes/clients (in absence of government programme)
- In some models can use detailed data of ‘client’ e.g. NGO One Acre Fund

E.g. Ethiopia, Kenya, Nigeria, Uganda, Zambia

- Data not owned/kept by Government
- CCEs priced into premium
Government-led CCEs in India

Solutions 2016+ under PMFBY
Technology investment & training to increase accuracy, reliability & allow processes to be finalized in real time:

Government funded technology & training

Enumerators smart phone & moisture metres to:
- Georeference sample plots
- **Geotag enumerators’ visits**
- Georeference and timestamped **photographs** and crop cuts videoed
- Measure grain moisture in the field with moisture meters
- **Send data to central server directly** from the field
- Auditing of CCEs carried out in near real time.

Crop cutting experiment sample data

- **Crop Name:** Wheat
- **Plot Size:** 0.5
- **Cultivator Name:** Rabhaji kishan
- **Type of Crop:** Mono
- **CropRatio:** 0
- **CCE Date:** 2011-03-27
- **CCE_count:** CCE1
- **Weight(kg):** 25
- **Primary Worker:** Mayura gaikwad
- **Supervisor:** Deshmukh agrl office
- **Village Commity:** Sarpanch
- **NO.OF.Bundles:** 40
- **Weight Of Bundles:** 80
- **Cause:** No Low Yield
- **Department:** Zilla Parishad Department
New technology for improving yield estimates

Potential game changer for AYII - overcoming issues with CCEs leading to huge efficiencies

Remoteely sensed average yield estimates

- No CCEs or reduced CCEs
- Moral hazard reduced
- Timely availability of data
- Relatively untested
- Requires good historical yield data for calibration & validation
- Farmer education is more important to avoid misunderstandings

E.g. Viet Nam, India

India: YES-TECH

- Government conducted R&D and approved roll-out in 2023
- Objective: blend technology-based assessment with manual CCE to eventually reduce dependency on manual methods in future and improve transparency
- Data used can be – remote sensing data, soil & weather data, crop yield, photo analytics, etc.
- Initiated with estimation of wheat and paddy, then expand
- Technology-based assessment will be blended with manual CCEs:
  - Recommended that technology assessment should at least 30% weight
  - National implementation partners and mentor agencies have been approved empaneled
  - YES-TECH manual prepared by the committee under MoA to guide implementation
- 2 states have started pilot implementation and 2024+ expected scale-up in other states

Source: Deloitte, India
AYII How? Implementation Considerations Summary

- **What existing government data that can be built on** (CCEs/historical production and crop yield data) - for which crops, and down to which level?
- **Phasing**: can reduce UAI size as more CCEs are collected

- **What method of CCEs should be defined?** (e.g. FAO; WBG best practice Crop Cutting Yield Estimation Procedures Guidelines)

- **Who should be responsible for conducting CCEs?**

- **Who should be responsible for auditing CCEs** required by insurers/reinsurers?

- **Who funds CCE costs**: staffing, equipment, technology, training, data management system, auditing; sensitization of farmers about CCEs?

- **What role should insurers play** in the CCE program?
Area Yield Index Insurance: How?
Contract Design & Rating Considerations
Steps in design and rating of an AYII Contract

After defining UAI:

- **Step 1**: Collect historical crop yield data for each UAI
- **Step 2**: Detrend data
- **Step 3**: Calculate the 'Normal Average' or expected yield for each crop and UAI
- **Step 4**: Define insurance coverage level
- **Step 5**: Conduct Historical Burning Cost Analysis
- **Step 6**: Estimate Insurance Premium Rate

**Notes**:
- Used to determine the reference yield level & the loss history of the UAI.
- Ideally minimum of 15 -20 years historical annual average yield data for each UAI.
- Yield data for lowest administrative division available e.g. ward level in Kenya.
- Once scheme is operational and dedicated yield series at UAI level will be developed progressively → helps make adjustments, e.g. to UAI.
Step 2. Detrend data

Key Takeaways

Key assumption is that past experience is a good guide to probability of future yields

Need to be careful: adjust for trends over time and look out for step changes (change in cropping practices or technology?)
Step 3. Calculate the average or expected yield per insured crop and UAI

**Key Takeaways:**
- Expected yield is a key driver of payouts and premiums → informs trigger thresholds
- **Simplest approach:** take average of past 3 or 5 or 7 years’ actual area yields.
  - E.g. India. In past used average of the middle 3 of past 5 years (after eliminating years with the highest and lowest annual yields). BUT found 5 years not always representative. Now uses average of 7 years (after eliminating 2 bad years).
- **Alternative approach:** statistically detrend time-series. Necessary when crop yields are increasing (or decreasing) over time.
- **Too short yield data time-series:** can distort average → leading to no or low payouts, or the opposite.
Step 4. Define insurance coverage level

The trigger yield is an agreed % of the expected yield

**Process:**
1. Agree on trigger yield that will be offered to farmers:
   - Coverage level can range from 50% to 90% of the expected yield.
2. If Trigger Level = 80%
   - Expected Yield = 1000 Kg./Ac.
   - Trigger yield = 1000 * 80% = 800 Kg./Ac.
3. When setting trigger yield think about: vulnerability, affordability, economics of growing crops, source of financing (e.g. credit)

**KEY TAKEAWAYS: Trade-off**
- Lower average yield = less frequent payouts
- Higher average yield = higher premium
Step 5. Understand likely cost of payouts based on historical yields: Historical Burning Cost (HBC) rating method

What are the steps to price insurance policy with HBC?

**Step 1**: for historical years (ideally 15-20 years), for each crop and UAI: calculate when actual yields fell short of the trigger yield and the amount of yield shortfall.

**Step 2**: calculate the average annual shortfall as a percentage of the total insured amount = pure loss cost rate or burning cost.
Step 5i. Calculate pure loss cost rate with trigger yield set at 80% of average

If Actual Yield < Trigger Yield, then:

\[
\text{AYII Payout (PKR ac)} = \frac{(\text{Trigger Yield (Kg/ ac}) - \text{Actual Yield, (Kg/ ac)})}{(\text{Trigger Yield (Kg/ ac}) - \text{Exit Yield (Kg/ ac)})}
\]

Key Takeaways:
- Trigger yield below 80% in 2016 & 2020 = payouts
- 2020 exceptionally bad year
- The pure loss cost is 2% = (6% +23%) / 12

The pure loss cost is 2% = (6% +23%) / 12
Step 5i. Calculate the pure loss cost with trigger yield at 70% of long-term average

If Actual Yield < Trigger Yield: then:

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\text{AYII Payout (PKR)} = \frac{(\text{Trigger Yield (Kg./Ac.)}) - \text{Actual Yield, (Kg./Ac.)}}{(\text{Trigger Yield (Kg./Ac.)}) - \text{Exit Yield (Kg./Ac.)}}
\]

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Yields (Kg./Ac.)</th>
<th>Trigger Yield (80% coverage level) (Kg./Ac.)</th>
<th>Exit Yield (0% Exit level) (Kg./Ac.)</th>
<th>Amount of yield shortfall (Kg./Ac.)</th>
<th>Shortfall %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>838</td>
<td>512</td>
<td>-</td>
<td>-</td>
<td>0%</td>
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<tr>
<td>2013</td>
<td>966</td>
<td>512</td>
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<td>2014</td>
<td>787</td>
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<td>2016</td>
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<td>2017</td>
<td>1,018</td>
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<td>2018</td>
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<tr>
<td>2019</td>
<td>979</td>
<td>512</td>
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<td>0%</td>
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<tr>
<td>2020</td>
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<td>512</td>
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<td>62</td>
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<tr>
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<td>919</td>
<td>512</td>
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<tr>
<td>2022</td>
<td>761</td>
<td>512</td>
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<tr>
<td>2023</td>
<td>826</td>
<td>512</td>
<td>-</td>
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**Burning cost**

\[
732 \times 70\% = 512 \\
512 - 450 = 62 \\
62 \div 512 = 23\%
\]
Step 5i. Calculate the pure loss cost with trigger yield at 70% of long-term average

Go to menti.com

Enter code: 4428 3064

Question: what is the pure loss cost rate?

Choose one option:
  a. 0.5 %
  b. 1 %
  c. 2 %
Step 5i. Calculate the pure loss cost with trigger yield at 70% of long-term average

Key Takeaways:
- The pure loss cost is reduced to 1% = 12% / 12 with a lower coverage level of 70%
- 2016 shortfall is no longer covered when coverage level drops to 70%

If Actual Yield < Trigger Yield:
then:

\[
\text{AYII Payout (PKR)} = \frac{(\text{Trigger Yield (Kg./Ac.)} - \text{Actual Yield, (Kg./Ac.)})}{(\text{Trigger Yield (Kg./Ac.)} - \text{Exit Yield (Kg./Ac.)})}
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</tbody>
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Burning cost: 
- 732 * 70% = 512
- 512 - 450 = 62
- 62 / 512 = 23%

2016 shortfall is no longer covered when coverage level drops to 70%

\[
\text{Amount of yield shortfall (Kg./Ac.)} = 512 - 450 = 62
\]

\[
\text{Shortfall %} = \frac{62}{512} = 23%\]
Step 6. Estimate Insurance Premium Rate

Key Takeaways

- Guideline final commercial premium = pure loss cost x 1.4 to 2.0
- Some margins can be reduced with better operations, data, and product design
- Overall viable rates for SSA could be in the range of 5 to 10%

Source: Stutley, C. Rural and Agriculture Finance Programme
Summary on AYII for smallholder farmers in SSA

2000 to 2010 nearly all focus was on micro-level WII pilots in Africa, but most failed due to contract design and spatial basis risk.

Many practitioners argued AYII in Africa was not possible because of:

- The mixed cropping farming systems of most smallholder farmers
- Lack of accurate historical area, production and yield data at local (e.g. ward) level to construct index, and
- The lack of a capability in the public sector to conduct CCEs at time of harvest to establish the actual average yield for payout purposes.

But over past 7 to 8 years it has been shown to be possible.

Now both public and private sectors are investing in CCE capabilities.

AYII is showing to be an insurance product which overcomes many of the drawbacks of MPCI and WII and this benefiting small scale farmers in SSA.

Going forward machine learning, AI, RS technology, smart sampling and drone technology are likely to support AYII expansion and to rationalize the number of CCEs required. India under revamped PMFBY is at the forefront of this technological revolution.
Thank You

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