The challenge

Centuries of nutrient mining on farms in the undulating landscape of Ethiopia has resulted in severely eroded and degraded soils that produce **40% less than the global average**.

The potential yield gap is huge. Yields in farmers’ fields are three times less than what is recorded in research fields.

Soil fertility decline is considered as the major cause for decline in per-capita food production.

Low crop response to fertilizers is a major concern despite the Ethiopian government investing in accelerating fertilizer usage and creating soil maps with recommendations to guide farmers.

The need for fine tuning the recommendations was identified following feedback from farmers and regional governments.

The solution

Research organizations and development NGOs were consulted to address the issue.

This report brings to you **TWO STUDIES IN WHEAT-BASED FARMING SYSTEMS** led by ICRISAT that offer solutions.

Key finding of the studies:

Site-specific nutrient management can double yields and reduce costs.
**BACKGROUND: FARMING IN ETHIOPIA**

**Soil-related problems**

- **Low productivity**
  - Average cereal yield:
    - Global: >3 t/ha
    - Ethiopia: 1.8 t/ha

- **Declining soil fertility**
  - Cost of loss of soil and essential nutrients is estimated at 3% of agricultural GDP
  - USD*106 million (≈1994 $)

- **Undulating landscape**
  - Fertility and topography varies widely between farms and within farms.

- **Low fertilizer application**
  - Accounts for one of the lowest in sub-Saharan Africa

- **Population pressure**
  - Traditional soil fertility management practices such as long-term fallows have been diminishing. Farmers are forced to farm non-cultivable lands.

- **Soil erosion-degradation**
  - Hillslopes are erosion prone. Applied fertilizers are washed away when it rains.

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**STEPS TAKEN BY THE ETHIOPIAN GOVERNMENT**

1. **Imported fertilizer**
   - (Nitrogen and Phosphorus)
   - 1994: 200,000 t
   - 2014: 894,000 t

2. **Soil fertility atlas**
   - Work on maps* for 18,000 agricultural kebeles was started by the Agricultural Transformation Agency (ATA-Ethiosis) in 2012

3. **5 fertilizer blend plants**
   - These plants are managed by five Farmer Cooperative Unions for more customized fertilization recommendations per district.

4. **Fine tuning earlier recommendations**
   - Farmers and regional governments inform that soil maps are not yet accurate enough to assure potential benefits to farmers applying mineral fertilizers. There is a need to:
     - Update them with contemporary technologies and analysis.
     - Fine tune recommendations by consulting research organizations.

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1 CSA, 2008; 2 Bojo & Cossells, 1995

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*In close collaboration with the African Soils Information Services (AFSIS), under the Ministry of Agriculture and Natural Resources, Ethiopia.

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3 International Livestock Research Institute, 2017
**APPROACH ADOPTED TO FINE TUNE RECOMMENDATIONS**

1. Conducted fertilizer trials
   - >600 experiments both on-farm and on-station in six wheat belts
   - Capitalized on earlier attempts by ATA and other stakeholders

   - Various combinations of Nitrogen (N), Phosphorus (P), Potassium (K), Sulfur (S) and Zinc (Zn) were used on different landscapes

3. Identified homogeneous cropping management zones
   - Used landscape positions as proxy indicators of differences in crop response. The indicator was developed by assessing the degree of correlation among soil and topography factors:
     - Fertility
     - Slope
     - Organic carbon
     - Water-holding capacity
     - Texture
     - Footslope
     - Midslope
     - Hillslope

4. Decision support tools developed
   - Based on the findings, decision support tools were developed for the wheat-based farming systems to guide extension agents, district officers and farmers to target landscape niches with specific soil fertility management options, particularly mineral fertilizers

5. GIS-based analysis
   - Implemented to interpolate potential niches of the respective response levels

**Spatial map of the nutrient response levels in Lemo and Endamohoni districts (study sites)**

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Nutrient Response Levels:
- **High**
- **Moderate**
- **Low**
- **Very low**
- **Kebele boundaries**
- **Experimental sites**

Upper Ghana Kebele (left) Tsibet and T/Haymanot Kebeles (right)
The recommendations suggested in this fact sheet could be used for crops with similar features such as **barley**, **sorghum** and **millets**.
Case study 1
**Lemo District: SNNPR**

**Site-specific Nutrient Recommendation for Wheat-based Farming**

**Location**

- **Hadiya Zone, SNNPR, Ethiopia**

**Topography and soils**
- Gentle and undulating topography
- Mid-altitude range: 1960 to 2720 masl`
- Soil derived from highly soft weathered rocks
- Susceptible to gully erosion
- Predominantly Nitosols, deep, well-drained and acidic

*Meters above sea level

**DECISION GUIDE for fertilizer application**

If your farm is...

<table>
<thead>
<tr>
<th>Fertile, flat, soil is deep, clay or loam, crops remain green during dry spells</th>
<th>Not fertile, undulated, shallow soils, sandy or gravelly, crops dry fast during dry spells</th>
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**Landscape position is...**

- **FOOTSLOPE**
- **MIDSLOPE**
- **HILLSLOPE**

**Fertilizer requirement is...**

<table>
<thead>
<tr>
<th>Urea</th>
<th>NPS</th>
<th>KCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 kg/ha</td>
<td>180 kg/ha</td>
<td>65 kg/ha</td>
</tr>
<tr>
<td>75 kg/ha</td>
<td>60 kg/ha</td>
<td>65 kg/ha</td>
</tr>
<tr>
<td>75 kg/ha</td>
<td>60 kg/ha</td>
<td>35 kg/ha</td>
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**Response to fertilizer...**
- High - Medium
- Medium - Low
- Low - Very low

**Expected yield is...**
- High - Medium: 6.5 - 4.0 t/ha
- Medium - Low: 4.0 - 2.5 t/ha
- Low - Very low: 2.5 - 1.5 t/ha

| Well managed* | Poorly managed |

For poorly managed hillslopes with <1.5 t/ha yield: No mineral fertilizer, apply organic amendments only.

* Use of agronomic packages – appropriate variety, timely planting, weed management and water saving practices.

**Major crops**
- Barley
- Wheat
- Field pea
- Faba bean
- Potato
- Teff
- Chickpea
- Ensete (Ethiopian banana)
- Haricot bean
- Fenugreek
- Multipurpose legumes for grain (in good season), fertility management and livestock feed

**Major livestock**
- Sheep
- Goats
- Cattle
- Poultry
- Horses
- Bees

**Location**

- **98.6%** Tepid sub-moist mid highlands
- **1.4%** Cool sub-moist mid highlands

**Weather**
- Extended rainfall from March-October
- Slight depression in June.

**Monthly rainfall**

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<th>May</th>
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<th>Aug</th>
<th>Sep</th>
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<th>Nov</th>
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**Area**

- **15%** Eutric Nitosols
- **25%** FOOTSLOPE
- **15%** HILLSLOPE
- **5-30°** ISOLINE
- **25%** Nitosols
- **100%** Nitosols
- **25%** FOOTSLOPE
- **60%** MIDSLOPE
- **15%** Stony leptosols
- **15%** HILLSLOPE
- **60%** MIDSLOPE
- **15%** Stony leptosols
- **5-30°** ISOLINE

**Topography and soils**

- Gentle and undulating topography
- Mid-altitude range: 1960 to 2720 masl`
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- **5-30°** ISOLINE
Case study 2
Endamohoni District
Site-specific Nutrient Recommendation for Wheat-based Farming

Location

46% Tepid sub-moist mid highlands
54% Cool sub-moist mid highlands

Topography and soils
- Mountainous landscapes
- Altitudinal range: 1690-3890 masl
- Soil fertility is dependent on
  - Erosion deposition
  - Presence of conservation structures

Weather
- Recurrent drought and extreme events.
- Main growing season (Meher) - July to Sep
- Rains (Belg) unpredictable from March to May

DECISION GUIDE for fertilizer application

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<td>Photos: T.Amede, ICRISAT</td>
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Fertilizer requirement is...

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- Medium - Low
- Low - Very low

Expected yield is...
- 8.0 - 4.5 t/ha
- 4.5 - 2.5 t/ha
- 2.5 - 1.5 t/ha

For poorly managed hillslopes with <1.5 t/ha yield: No mineral fertilizer, apply organic amendments only.

Major crops
- Barley
- Wheat
- Field pea
- Potato
- Neug (an oilseed crop)
- Faba bean
- Grass pea
- Lentil

Major livestock
- Sheep
- Goats
- Cattle
- Poultry
- Horses
- Bees

* Use of agronomic packages – appropriate variety, timely planting, weed management and water saving practices.
Key findings

Why location-specific targeted fertilizer recommendation is needed:

- **Gaps in present system:** Existing fertilizer recommendations do not take into account farming systems, landscape positions and cropping systems.
- **Diverse altitude and agroecology:** Mountain peaks and valley bottoms can be found within very short proximity.
- **Landscape positions dictate fertilizer needs:** Distinct features in terms of slope, water-holding capacity and inherent soil fertility dictate the amount and type of fertilizer to be used.
- **Human factors:** Farms around homesteads and valley bottoms are favored for application of fertilizer, organic manure and crop residue due to proximity and limited risk of crop failure.
- **Differing soil fertility gradients:** This was created over time by the combination of natural and human factors. It requires appropriate and site-specific management practices.

Water management interventions

Exponential yield benefits from application of mineral fertilizers was noticed when accompanied by enhanced water management interventions at farm and landscape scales.

Soil and water conservation as well as use of organic amendments would be important to improve soil health and thereby increase the yield response to applied nutrients.

Application of fertilizers and soil amendments

**Nitrogen, Phosphorus and Potassium**
- Showed dominant yield response
- Highest benefit is obtained in the footslopes

**Sulfur and Zinc:**
- Crop yield response was limited, with yield advantage <5%
- Improvement in grain quality

**Lime**
- Majority of the soils are moderately to strongly acidic. Application of lime is advised to further increase yield response to applied nutrients.

**Organic amendments**

Hillslopes experience heavy erosion. Improving the soil quality through soil and water conservation structures and planting legumes as a precursor crop could sustainably improve the soil health/productivity. Our experimentation demonstrated that seasonal rains here are sufficient enough to get a good deal of biomass from legumes such as lablab, lupin and vetch (using root and above ground biomass) for better yield of succeeding crops.
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• Regional research institutions: Amhara Regional Agricultural Research Institute, Southern Agricultural Research Institute, Tigray Agricultural Research Institute, Oromia Agricultural Research Institute
• Federal research institutions: Ethiopian Institute for Agricultural Research
• Bureau of Agriculture: Endamekoni (Tigray), Basona Worena (Amhara), Lemo (SNNPR), Worreilu (Amhara) and Sinana (Oromia)

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References: