MAPPING RISKS AND OPPORTUNITIES OF CLIMATE CHANGE TO SUBSISTENCE FARMERS IN EAST AFRICA

By Peter Mwangi
Introduction

- Developing world has predominantly subsistence farmers for whom the on-farm agriculture and off-farm agricultural labor providers are the main source of food and income.

- SSA relies heavily on weather-sensitive agriculture i.e. subsistence farming.

- Vulnerability of subsistence farmers is greatly influenced by changes in climate and its variability (Ito & Kurosaki, 2009; Morton 2007)

- Hunger and poverty prevails hence prioritize investments and policy in this region in order to prevent the destructive impacts of future changes in climate on food production. (Stige et al., 2006; Lobell et al., 2008; Schlenker & Lobell, 2010)

- Crop yields may fall by 10 to 20% by the year 2050 because of global warming, droughts or even floods, but there are places where it will be much more severe (Jones & Thornton, 2003).

- Developing countries are more vulnerable to the effects of climate change mainly due to their low coping capacity or mitigation measures to adapt to climatic threats (Thomas & Tyman, 2005)

- High reliance on natural resources and climate dependent staple crops, exacerbates their vulnerability.
The mapping of climate change vulnerability enables the representation of local context within **vulnerability assessment** through the spatial rendering of geographically **heterogeneous determinants** of vulnerability and their interactions.
Concept

Start point approach, pressure-and-release conceptual model (Benjamin et al., 2011).

– Views vulnerability as a general characteristic generated by multiple factors and processes.
– It diagnoses inherent social and economic processes of marginalization and inequalities as the causes of climate vulnerability and seeks to identify ways of addressing these.
– Systematic understanding of human-environment interaction is a more holistic approach to vulnerability assessment.

Integrates climate exposure and the related coping capacity in agricultural areas that are sensitive to climatic change.

Vulnerability is a function of (Ericksen et al., 2011):

• **Exposure** to future threats in climate change i.e. temperature and precipitation on staple crops (Maize, Sorghum, Common bean, Teff, Rice and Cassava)

• **Sensitivity** to impacts of these threats

• **Coping capacity** to adapt to ongoing and future climate changes in the face of such threats
Indicator factors/variables

Selection of indicators for the vulnerability assessment was enabled by:

- Developing conceptual models of the relationship between climate, socio-economic activities and adaptive capacity and use this to select relevant vulnerability indicators. (*Preston et al.*, 2009).

- Selection of indicators is based upon theoretical linkages between different determinants of vulnerability and developing indices to measure vulnerability (*Adger & Vincent* 2005).

- With the recommendation above the most common and reliable indicator variables (based on literature review) were used to assess the vulnerability of climate change to subsistence farmers.
Vulnerability assessment

A

Climatic determinants that influence staple crop distribution

Distribution shifts of staple crop based on change in climatic condition

Level of Exposure

B

Socio-economic determinants sensitive climate conditions

Sensitivity indicator variables & thresholds

Level of Sensitivity

Vulnerability Assessment Distribution

C

Adaptation/Resilience determinants to climate change

Coping capacity indicator variables & thresholds

Level of Coping capacity
Vulnerability Assessment

Determinants

Exposure
- Future potential diversity of stable crops
  Measure the risks/opportunities of climate change to stable crops

Sensitivity
- Human population density
- Percentage of crop intensity
  Measure the reliance on agricultural resources

Coping Capacity
- Poverty level
- Time taken to markets
  Measure the resilience to climate change
Vulnerability assessment:

Resolution of 5 km i.e. an area unit of 25 km²

Using the WGS 84 coordinate system
Approach

Spatial Multi-Criteria Evaluation: using both empirical and expert knowledge analysis.

• **Exposure determinant** was based on present and future changes in climatic conditions that may potentially affect staple crop prevalence hence diversity. Based on empirical analysis.

• **Sensitivity and Coping capacity determinants** were based on human density, % of crop intensity, poverty level and time taken to markets variables from literature review.

• **Thresholding variables** classify variables based on what is considered as favorable or unfavorable conditions, based on expert knowledge. It enables compatibility among variables and scoring.

• **Variable domain approach** to express the level of vulnerability (risks) but also opportunities of climate change to subsistence farmers.
Crop suitability modeling, present (2000) and future (2050)

Determinant 1: Exposure (to Climate change)
- Terrain/Soil (invariant)
- Temperature for 2000 and 2050
- Length of Growing Period for 2000 and 2050
- Precipitation for 2000 and 2050

Determinant 2: Sensitivity (Reliance to climate based resources)
- Human Population Density
- % of cropland

Determinant 3: Coping Capacity (Resilience to climate change)
- Poverty level
- Access to markets
- Agricultural Areas

Using Maxent

- Climate exposure risk and opportunity index map based on changes in the crops distribution
- Sensitivity index map based on indicator variable thresholds

Using ArcGIS

Vulnerability Mapping using domain approach i.e. Exposure, Sensitivity and Coping Capacity domains in Agricultural areas
Results & Explanation
Brewing the Exposure determinant

Beans Potential Distribution 2000

Beans Potential Distribution 2050

Minus

\[
\begin{bmatrix}
1 & -1 \\
0 & 0 \\
0 & -1 \\
1 & 0 \\
\end{bmatrix}
= \\
\begin{bmatrix}
0 \\
0 \\
-1 \\
1 \\
\end{bmatrix}
\]

Aggregate for all staple crops
**Exposure determinant**

Expressed by the change in no. of potential staple crop varieties in year 2050 at a given area unit.

The more the crop varieties in 2050 in an area, the lack of exposure to risks hence opportunities for crop diversification due to climate change.

The fewer the crop varieties in 2050 the more the exposure to risks of loss in crop diversification due to climate change.
## Exposure Amount

<table>
<thead>
<tr>
<th>Level</th>
<th>Score on crop variety at year 2050</th>
<th>Area Covered (km²) at year 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive effect of climate change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Opportunity)</td>
<td>-3</td>
<td>3,600</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>26,625</td>
</tr>
<tr>
<td></td>
<td>-1</td>
<td>176,000</td>
</tr>
<tr>
<td>No change</td>
<td>0</td>
<td>1,590,025</td>
</tr>
<tr>
<td>Negative Effect of climate change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Risk)</td>
<td>1</td>
<td>811,500</td>
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<tr>
<td></td>
<td>2</td>
<td>475,550</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>195,200</td>
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<tr>
<td></td>
<td>4</td>
<td>80,275</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>17,900</td>
</tr>
</tbody>
</table>
Preparing the Sensitivity determinant

Aggregate cropland intensity and Human Population Density

Aggregate cropland intensity and Human Population Density
Sensitivity Determinant

Reliance based on crop farming & human population density.

At high crop farming & population density the sensitivity level is high.

Sensitivity level is low when either of the variable are high.

Without any of the variables being high there is no sensitivity.
Preparing the Coping Capacity determinant

Aggregate Poverty level and Travel time to urban centers

Aggregate Poverty level and Travel time to urban centers
Vulnerability score is the inverse of coping capacity (resilience).

High vulnerability score means high poverty level (>40%) and lack of access to market centers for trade.

Low vulnerability score means either poverty level is high or there is no access to market centers for trade.

Vulnerability score is 0 it means the area has low poverty level (<40%) & lack of access to market centers for trade.
Risk mapping

Combines all the three determinants using a domain approach system to graphically express the level of vulnerability across the study area.

Vulnerability level starts at a lowest of very low exposure, no sensitivity & have a high coping capacity.

To a highest vulnerability of very high exposure, high sensitivity & have no coping capacity.
Opportunity mapping

Combines Opportunity (from Exposure) & Benefits (from Sensitivity) determinants using domain approach system to express the level of opportunity across the study area.

Opportunity level is at the lowest; with low opportunity & no benefit.

To the highest; with high opportunity & high benefit.
Discussion

• Integrated vulnerability assessment shows that social vulnerability may exist independently to climate change but may **exacerbate** when exposed to the risks of climate change.

• Those at the highest risk of climate change are the ones that are highly reliant on climatic based resources (i.e. stable crops) and face the dual challenge of negative exposure of climate change with no coping capacity.

• Two perception scenario, based on whether climate change actually brings about risks or opportunities to a particular community/area.

• Communities that face a positive exposure, hence opportunity, to climate change may enjoy these benefits the most if they are a large population that exclusively relies on staple crop farming.
Conclusion

• The vulnerability assessment spatially identifies the risks & the opportunities of climate change to small holder subsistence farmers who exclusively rely on stable crops in the 4 study countries.

• This equips stakeholders to make informed decisions and suitable policy that mitigate adversities & also harness opportunities of climate change.
Many Thanks!

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