Background information and objectives

Study of the Taita Hills and Kilimanjaro transects by the icipe-led CHIESA project focuses on the incidence of climate change on agricultural systems in Kenya, which rely heavily on climate conditions such as rainfall.

As climatic conditions change, so do farming systems and practices. Cereal harvests in recent years have gradually decreased and can barely support rapidly growing human populations for a full year, thus food insecurity. East African countries are particularly prone to extreme climatic conditions like drought and floods, as projected changes in temperature are estimated between 1.3°C and 2.1°C by 2050.

Where crop production and ecosystem services are concerned, these temperature changes are likely to affect diversity and populations of insect pests and their damage to cereal crops growing in the field and the harvested grain. These changes influence the economy of smallholder farmers that dominate Kenya’s agriculture.

The full nature and magnitude of impacts of climate change, positive or negative, is not known. This is because there is no data from East Africa on the likely response of the above interactions to climate change that would form a basis for estimations.

Generally, soils are comprised of variable quantities of important crop minerals such as Nitrogen (N), Phosphorus (P) and Potassium (K) depending on the nature of parent soil forming material and biological/physical processes. For instance, soils derived from rocks are generally very rich in nutrients and are fertile, while soils derived from sand are poor in nutrients and are relatively infertile. Under natural conditions, most nutrients are recycled from plant, to soil and back to plant.

Soil nutrients lost, for instance through leaching during rain, depend on how strongly the nutrient is bound to the soil constituents. Weakly bound nutrients, such as nitrates (NO$_3^-$) are rapidly leached, while strongly bound nutrients, such as phosphates (PO$_4^{3-}$) suffer little loss. The losses by leaching must be replenished to maintain the fertility of the soil. If any nutrient is repeatedly taken from farms/fields by crops grown, then the soil will ultimately become depleted in that nutrient, and the fertility of the soil will decrease. In this context, it is important to characterize the soil in order to understand the continuum; climate-soils-plants-insect pests-natural enemies.

The CHIESA maize project has undertaken extensive physical-chemical analysis of soils along each transect (Taita Hills and Kilimanjaro), and has shared results with farmers to develop and implement action plans for soil fertility restoration. Each farmer has received a booklet with customised results on their farm's soil health, with recommendations for corrective solutions to improved soil quality for crop cultivation.

Transects studied

The Taita Hills and Kilimanjaro transects are characterized by rapid change in altitudinal gradient (altitude), and by a significant variation in temperatures and rainfall patterns along the gradient. Mean annual temperature (°C) and rainfall (mm) of the localities of the Taita Hills and Kilimanjaro transects for 2013 are summarized below.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Locality</th>
<th>Altitudes (m.a.s.l)</th>
<th>Daily temperature</th>
<th>Nightly temperature</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taita Hills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kipusi</td>
<td>818 - 871</td>
<td>27.3</td>
<td>20.5</td>
<td>41.3</td>
<td></td>
</tr>
<tr>
<td>Dembwa</td>
<td>1083 - 1102</td>
<td>25.6</td>
<td>18.5</td>
<td>40.4</td>
<td></td>
</tr>
<tr>
<td>Josa</td>
<td>1340 - 1358</td>
<td>21.4</td>
<td>18.1</td>
<td>88.0</td>
<td></td>
</tr>
<tr>
<td>Mbengonyi</td>
<td>1467 - 1490</td>
<td>21.3</td>
<td>16.6</td>
<td>65.5</td>
<td></td>
</tr>
<tr>
<td>Kighala</td>
<td>1678 - 1709</td>
<td>20.1</td>
<td>15.8</td>
<td>87.6</td>
<td></td>
</tr>
<tr>
<td>Vuria</td>
<td>1797 - 1814</td>
<td>19.4</td>
<td>15.1</td>
<td>121.1</td>
<td></td>
</tr>
<tr>
<td><strong>Kilimanjaro</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miwaleni</td>
<td>714 - 765</td>
<td>28.3</td>
<td>22.1</td>
<td>120.5</td>
<td></td>
</tr>
<tr>
<td>Uparo-Iwaleni</td>
<td>891 - 987</td>
<td>25.2</td>
<td>20.3</td>
<td>40.1</td>
<td></td>
</tr>
<tr>
<td>Uparo</td>
<td>1158 - 1188</td>
<td>23.3</td>
<td>18.3</td>
<td>71.4</td>
<td></td>
</tr>
<tr>
<td>Kopachi</td>
<td>1365 - 1402</td>
<td>21.8</td>
<td>17.7</td>
<td>112.7</td>
<td></td>
</tr>
<tr>
<td>Nduoni</td>
<td>1550 - 1561</td>
<td>21.0</td>
<td>16.3</td>
<td>141.4</td>
<td></td>
</tr>
<tr>
<td>Marua</td>
<td>1667 - 1683</td>
<td>20.0</td>
<td>15.0</td>
<td>159.0</td>
<td></td>
</tr>
</tbody>
</table>

Table summary of Mean annual temperature (°C) and rainfall (mm) of the localities of the Taita Hills and Kilimanjaro transects for 2013

Courtesy of: Sizah Mwalusepo/ CHIESA

Field view in Miwaleni (Kilimanjaro)
Photo by: Dr. Paul André Calatayud/ CHIESA
General Results

Soil sampling
For each altitude range and sampled farm, about 20g of soil from the surface (0-25 cm depth) was collected in different parts of the cultivated area (dispatched in a way to characterise the overall cultivated area) to obtain homogenous soil mixtures of about 200g of soil.

Parameters evaluated by Cropnuts (Crop Nutrition Laboratory Services, Nairobi)
The pH (indicator of soil acidity levels), the Cation-Exchange Capacity (C.E.C, measure of soil fertility, nutrient retention capacity, and the capacity to protect groundwater from cation contamination), Electrolytic Conductivity (E.C., measure the level of salts in soil) and the organic matter (indicator of soil health) were analyzed by spectroscopy and colorimetry.

In this flyer, we report only the extrapolation of the distribution of pH, organic matter, phosphorus (P), potassium (K) and aluminium (Al) in soils along the altitude of each transect.

Aluminium extrapolation maps (above) for Taita and Kilimanjaro respectively.
High amount of aluminium is toxic for plants and also reduces the amount of nutrients that plants can make use of, such as phosphorus. Growers specifically target available aluminium by treating the soil. Maps by: Macharia Kabiro/icipe
Most plants cannot tolerate a wide range of acidity in the soil. When soil acidity changes, the solubility of a number of metal ions also changes. Plant growth is really affected by the varying concentration of these metals in solution rather than by the acidity itself.

Soil organic matter (SOM) is directly and positively related to soil fertility and agricultural productivity potential. There are many advantages to increasing or maintaining a high level of SOM, including reduced bulk density; increased aggregate stability; resistance to soil compaction; enhanced fertility; reduced nutrient leaching; resistance to soil erosion; increased biological activity; reduction of greenhouse gases by soil C sequestration. In most agricultural soils, organic matter is increased by leaving residue on the soil surface, rotating crops with pasture or perennials, incorporating cover crops into the cropping rotation, or by adding organic residues such as animal manure, litter, or sewage sludge. Maps by: Macharia Kabiro/icipe
Phosphorus extrapolation maps (above) for Taita and Kilimanjaro respectively
Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. It promotes root growth and winter hardiness, stimulates tillering, and often hastens maturity.

Potassium extrapolation maps (below) for Taita and Kilimanjaro respectively
Potassium is an essential nutrient for plant growth. Potassium for plants stimulates early growth; increases protein production; improves the efficiency of water use; improves resistance to diseases and insects. Maps by: Macharia Kabiro/ icipe
For more information about CHIESA’s research on maize stem borer, please contact:

Dr Bruno Le Ru - IRD/ icipe
bleru@icipe.org

Dr Paul-André Calatayud - IRD/ icipe
pcalatayud@icipe.org

Sizah Mwalusepo - UDSM/ icipe
smwalusepo@icipe.org

Contributors:

IRD - NSBB (Noctuid Stem Borers Biodiversity group)
- Gerphas Okuku
- Anthony Kibe
- Boaz Musyoka
- Julius Obonyo
- Elijah Njuguna

• Dr. Tobias Landmann

ICIPÉ
- Macharia Kabiro

KEFRI
- Mary Gathara

IRD/ ICRAF
- David Williamson

www.chiesa.icipe.org

CHIESA Lead Partners:
University of Helsinki (Finland), University of York (United Kingdom),
University of Dar-es-Salaam (Tanzania), Sokoine University of Agriculture (Tanzania).