CHIESA

Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa

Increasing Knowledge, Building Capacity and Developing Adaptation Strategies

POLICY BRIEF 7
June, 2014

Photo by: Dr Bruno Le Ru/ CHIESA

Ecosystem services pest management

Climate Change and Impact on Maize Lepidopteran Stem Borers and their Natural Enemies

icipe

IRD Institut de recherche pour le développement

FORMIN.FINLAND.FI
MINISTRY FOR FOREIGN AFFAIRS OF FINLAND

Above left, a field of healthy maize crop and, right, a stalk of maize infested with *Busseola fusca (Bf)*. ***This species of stem borer attacks maize in various parts of Africa. Life cycle of*** *Bf* ***on next page.*** Photos by: Dr Bruno Le Ru, Dr George Ong'amo and Dr Paul-Andre Calatayud/ CHIESA

Introduction

It is widely accepted that the earth's climate has become increasingly warmer. Temperature has a strong and direct influence on insect development, reproduction and survival, and is considered the dominant environmental factor affecting insect pests. As a consequence climate change influences insects' geographical distribution and ultimately their injuriousness to crops.

Maize was introduced in Africa by Portuguese explorers at the beginning of the 16th century. It has since become African's most important staple food crop cultivated up to altitudes of 2700 meters above sea level (m.a.s.l.). Among the most important pest constraints to maize production in sub-Saharan Africa are Lepidopteran stem borers. These pests are most destructive at the larval stage, when they damage the plant by feeding on the leaf tissues, followed by tunneling and feeding within the stem and sometimes the maize cobs.

With losses estimated at between $1-2 billion each year in sub-Saharan Africa for maize only, current observed changes in climate are likely to reduce maize yield by 10 to 20%, by the year 2055.

What can we do about it?

The nature and magnitude of climate change impacts, positive or negative, are not exhaustively known. Further, there is no data from East Africa on the likely response of maize stem borer pests and their natural enemies to climate change. It is on this background that CHIESA WP5 (maize component) is assessing the risks and impacts of climate change on the general functional maize-biodiversity, particularly insect pests and their natural enemies.

Specifically, the team:

- Assesses diversity of maize stem borer pests along the altitudinal gradients and estimates the likely effects of climate change on their distribution
- Creates a catalogue of natural enemies and assesses potential effects of climate change on their distribution and association with respective host pests
- Investigates the roles and effects of different cultural farming practices applied in mitigating and stabilizing maize production. These include varieties, fertilizers, length of cycles and maize crop residues
- Estimates and models socio-economic impacts of climate change on maize production.

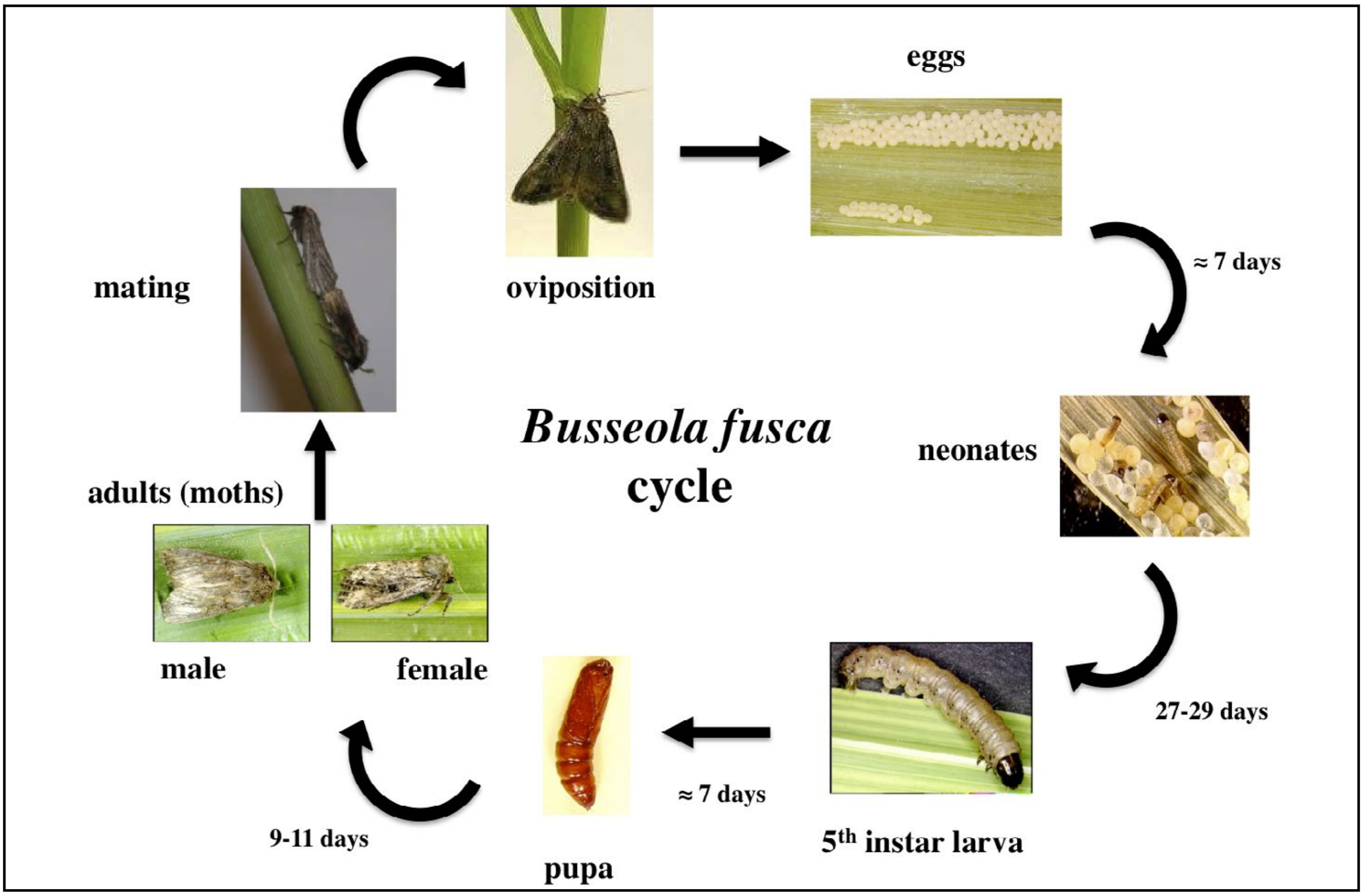
Maize lepidopteran stem borer pests and natural enemies in East Africa

Several stem borer species attack maize in various parts of Africa, but those of major economic importance in East Africa are the spotted stem borer *Chilo partellus (Cp)*, the sorghum stem borer *Busseola fusca (Bf)* and the pinky stem borer *Sesamia calamistis (Sc)*.

Chilo partellus is the most common pest in low altitude areas although its presence has been reported in higher altitudes, probably due to changes in temperature over the last two decades. *Busseola fusca* is more adapted to middle and high altitude conditions, while *S. calamistis* is found almost everywhere at low densities.

The stem borer pests are attacked by natural enemies, among them the larval wasps *Cotesia flavipes* and *C. sesamiae*, which attack *C. partellus* and *B. fusca* respectively. The occurrence of the two *Cotesia* species in different ecological regions is influenced by the geographic range of their respective suitable stem borer hosts, and probably by temperature preferences.

In order to reduce crop damage and control population growth, these species have been subjects of extensive



research in East Africa, since decades of biological control particularly using parasitoids have been found to be effective against the stem borer species.

How does climate change impact maize stem borer pests and their natural enemies?

Altitude, along with temperature preference, heavily determines live organism distribution. Insects vary in their population response to altitude, with different insects showing increasing, declining or no altitudinal trends in abundance. Population densities, particularly of herbivorous insects at any given altitude are ultimately determined by the interaction between the host plant, the insect and the associated parasitoids and predators. Moreover, the species composition of insect communities changes with altitude.
Thus, study of stem borer pest communities along altitudinal gradient, characterized by rapid change in climatic conditions, particularly temperature, is a good approach to analyze and understand climate driven change under various climate conditions.

This study is conducted along two transects; one on the slopes of Taita Hills near Wundanyi town in Kenya, and the other on the slopes of Mount Kilimanjaro near Moshi town in Tanzania, with an altitude ranging from 900 to 1800 m.a.s.l. A total of 60 farmers' cultivated maize plots (10 maize plots selected in 6 localities along both transects) have been selected. Random sampling of maize stems is carried out at regular intervals to capture the incidence and diversity of stem borer pests and their natural enemies. During sampling, parameters such as plant stage, number of infested plants per plot, stem borer density per plant, length of tunneling per plant, larval stage, species composition, and parasitism level are recorded.

In addition, life table experiments are conducted in laboratory conditions under constant and variable temperatures to determine the effect of temperature on the developmental time, survival, longevity and reproduction of the targeted stem borer pests, in order to predict different demographic parameters (number of generations, establishment index, etc), and to generate distribution maps of the stem borer pests and their main parasitoids under different climatic scenario after validation with the field data.

What do first observations show so far?

Field observations indicate very similar distribution of the three maize stem borer pests along the Taita hills and Kilimanjaro transects, and a clear difference in community

Above from left are** Chilo partellus**(larvae),** C partellus**(adult),** S calamistis**(larvae) and** S calamistis**(adult).** Chilo partellus **is the most common pest in low altitude areas,while** S. calamistis **is found almost everywhere at low densities. Photos by: Dr Bruno Le Ru/ CHIESA composition and infestation levels according to altitude. *Busseola fusca* is the main pest in higher altitudes, while *Chilo partellus* is the dominant pest in lower altitudes. In both transects the highest stem borer pest infestation is recorded between 1200-1500 m.a.s.l.

What are the expected outputs?

Available results allow for prediction of stem borer pest distribution along each transect based on temperature. These results show that an increase in temperature will have potentially serious consequences on the three stem borer pests, including boundary expansion to higher elevations areas and negative impact on maize production at mid-altitude areas.

Current studies focus on developing a mathematical model featuring different spatial data layers such as precipitation, soil characteristics (Silica, Nitrogen, C/N), and plant characteristics (such as number of cycles, cycle duration, etc) to evaluate their respective influence on stem borer pest distribution and incidence.

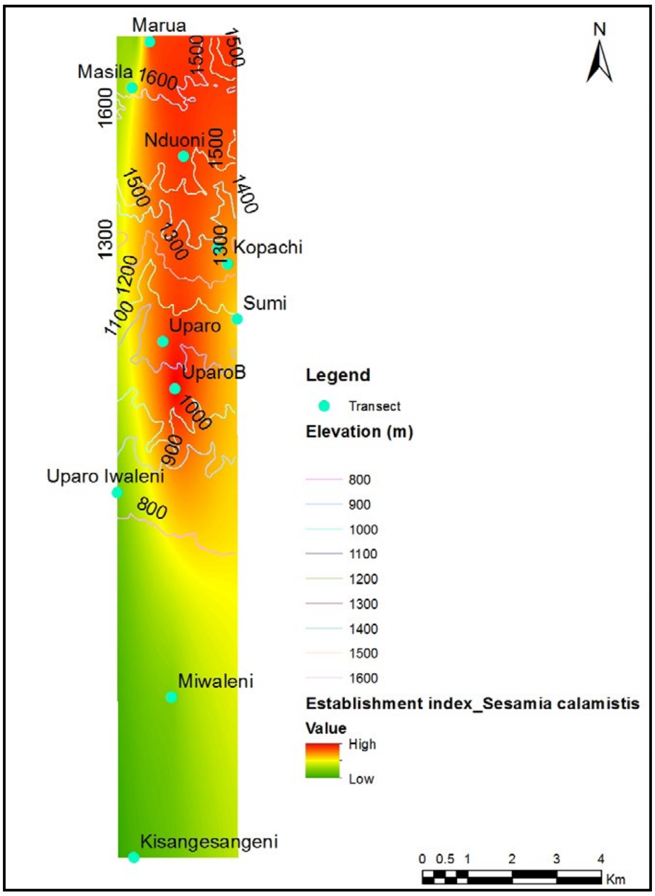
At the end of the project, we will be able to:

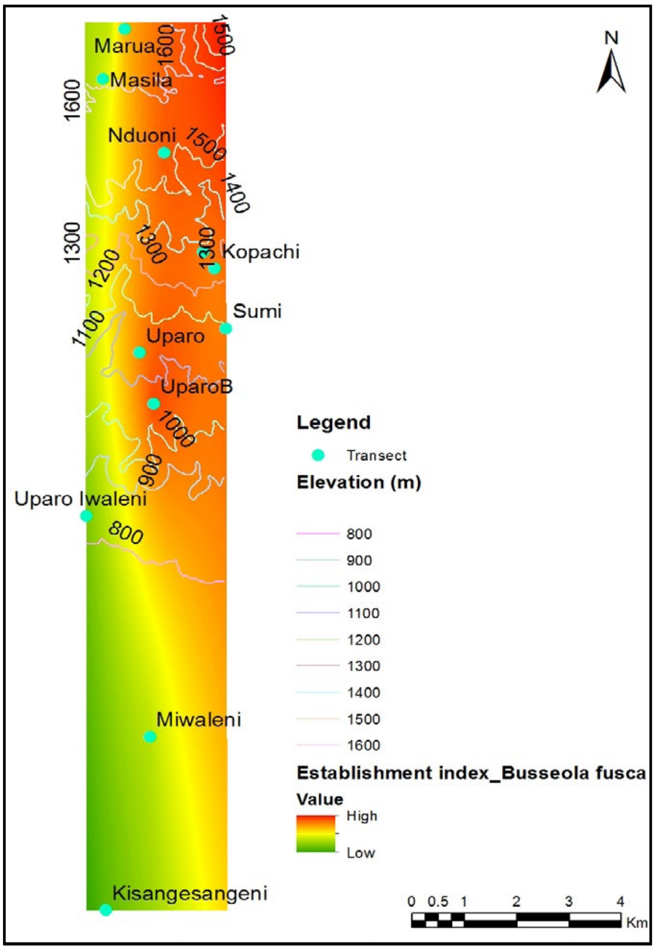
• Provide the scientific community with information about life history and demographic parameters of maize pests and their natural enemies

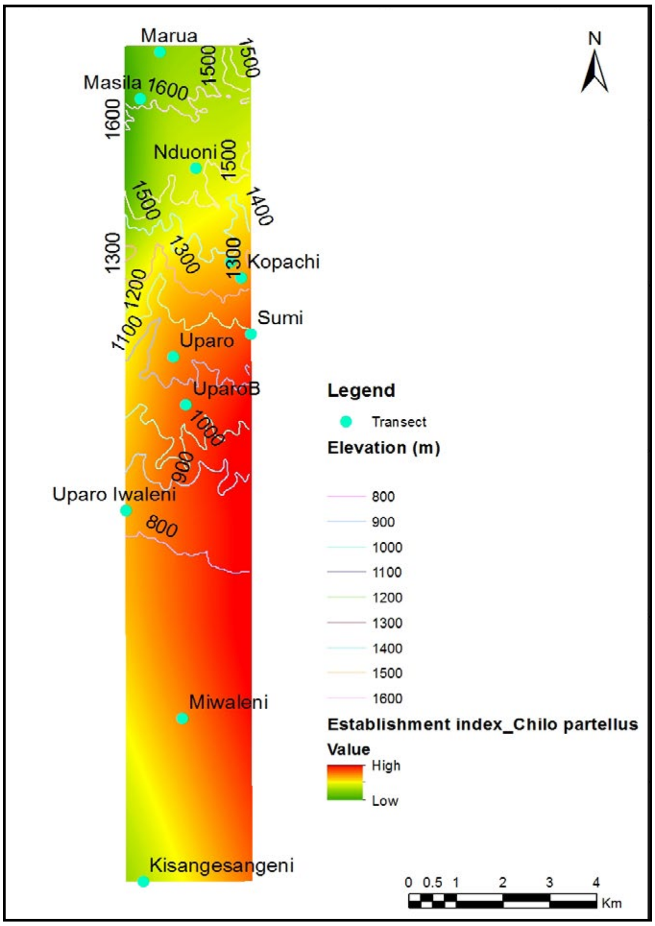
• Provide trends for pest risks according to different climate change scenario in the region

• Provide stakeholders of the studied areas with decision tools like maps and calendars for maize stem borer pest risks

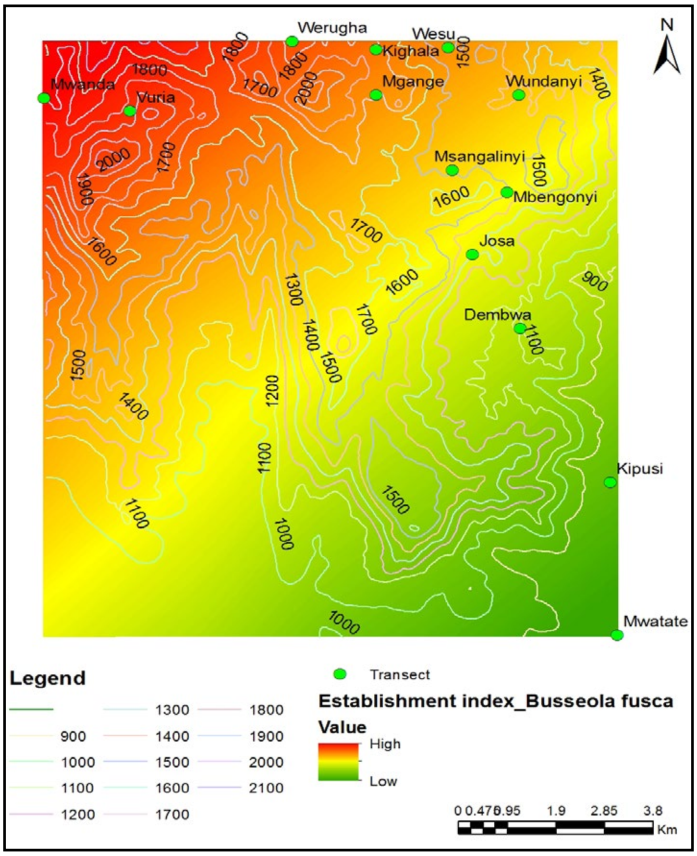
• Provide farmers with pest management recommendations (varieties, fertilizers, intercropping, and management of maize residues) according to elevation.

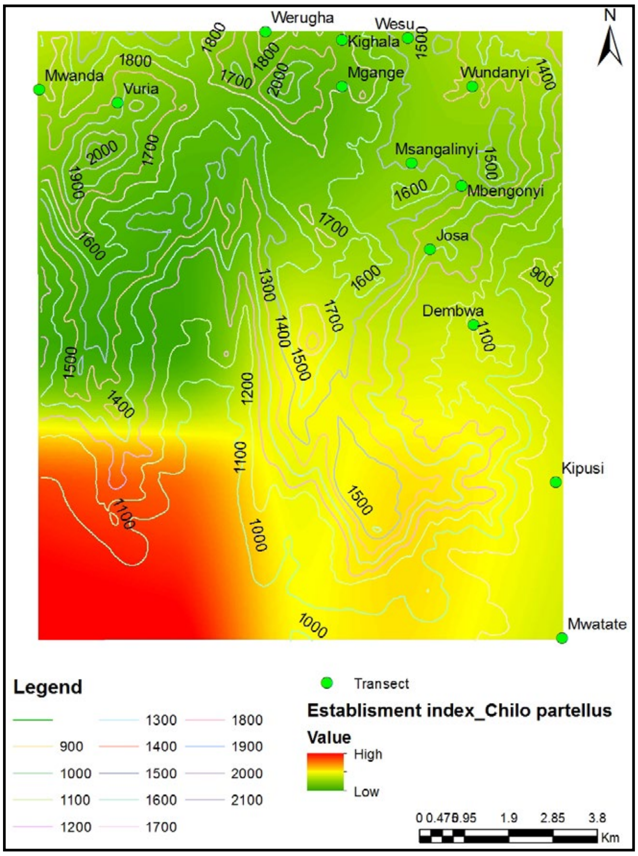


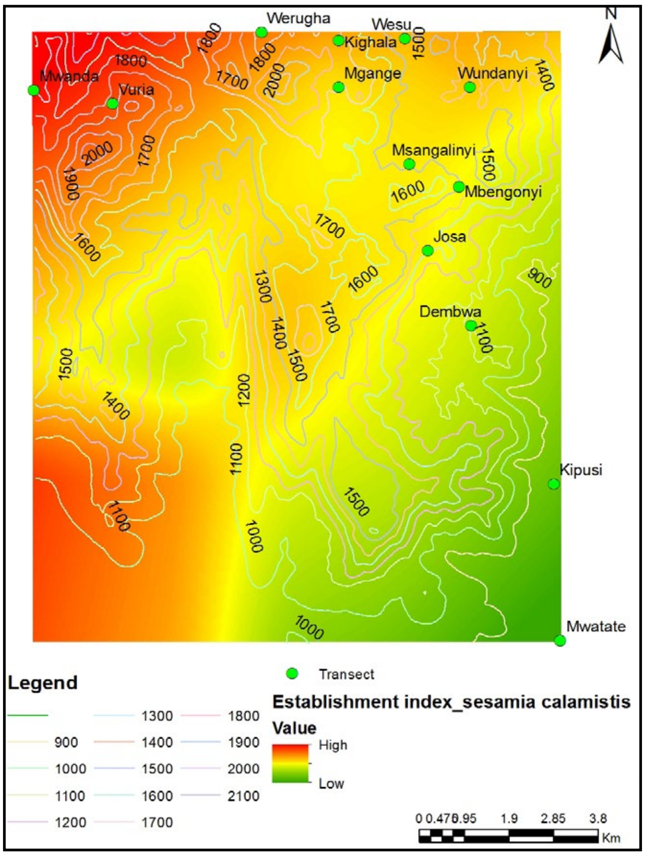


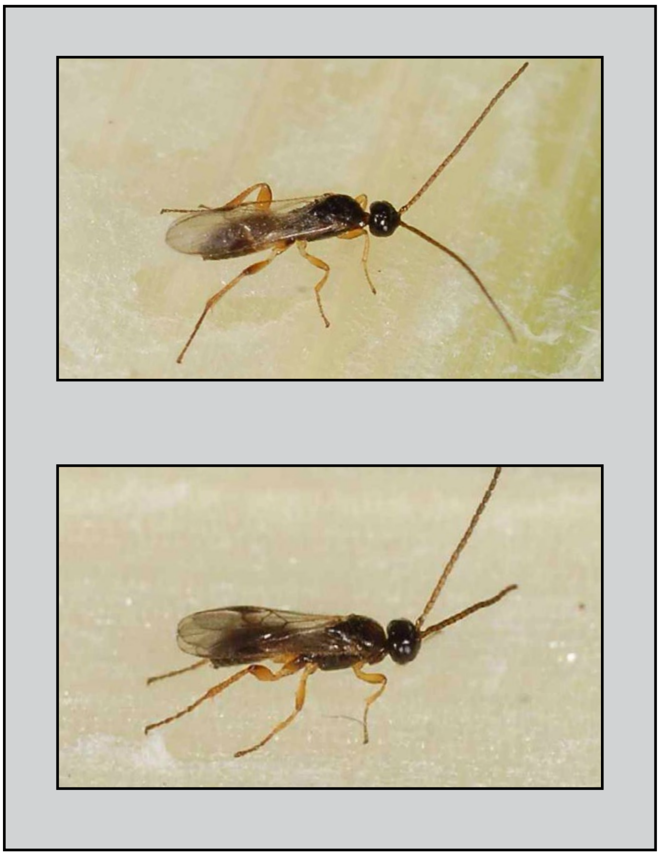


Distribution raster maps of the three species of stem borer in Kilmanjaro, Tanzania. Clockwise from top right, distribution of** Busseola fusca**,** Chilo partellus**, and** Sesamia calamistis**.
Maps by: Sizah Mwalusepo/ CHIESA









Distribution raster maps of the three species of stem borer in Taita Hills, Kenya. Clockwise from bottom left, distribution of *Sesamia calamistis*, *Busseola fusca*, ***and*** *Chilo partellus*.
Maps by: Sizah Mwalusepo/ CHIESA

The stem borer pests are attacked by natural enemies, among them the larval wasps *Cotesia flavipes* ***(top inset) and*** *C. sesamiae* ***(bottom inset), which attack*** *C. partellus* ***and*** *B. fusca* ***respectively. The occurrence of the two Cotesia species in different ecological regions is influenced by the geographic range of their respective suitable stem borer hosts, and probably by temperature preferences.***
Photos by: Dr Bruno Le Ru/ CHIESA

What is CHIESA?

The Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA) is a four-year research and development project aimed at increasing knowledge on the impacts of climate change on ecosystem services in the Eastern Afromontane Biodiversity Hotspot (EABH).

CHIESA is funded by the Ministry for Foreign Affairs of Finland, and coordinated by the International Centre of Insect Physiology and Ecology (icipe) in Nairobi, Kenya.

Through research and training, CHIESA will build the capacity of research communities, extension officers and decision makers in environmental research, as well as disseminate adaptation strategies in regard to climate change. The general areas for environmental research are in agriculture, hydrology, ecology and geoinformatics.

CHIESA activities focus on three mountain ecosystems in Eastern Africa, namely Mt. Kilimanjaro in Tanzania, the Taita Hills in Kenya and Jimma Highlands in Ethiopia. The project consortium monitors weather, detects land use/land cover change, and studies biophysical and socio-economical factors affecting crop yields and food security.

The project also builds the climate change adaptation capacity of East African research institutions, stakeholder organizations and decision-makers through research collaboration and training.

Together with local communities, the project will develop, test and disseminate climate change adaptation tools, options and strategies at the farm level.

Further, CHIESA provides researcher training for staff members of the stakeholder organizations, enhances monitoring and prediction facilities by installing Automatic Weather Stations, and disseminates scientific outputs to various actors from farmers to policy-makers.

WP5 - Assessment of Ecosystem Pest Management and Pollination

CHIESA involves farming communities at grass-root level as key collaborators. This collaboration is aimed at increasing their knowledge on various functional agro-biodiversity and their effects on productivity and production of selected crops, in the context of climate change. Functional agro-biodiversity in this case refers to the relationship between or status of insect pests and their natural enemies, pathogens, pollinators, soil engineers, decomposers etc.

CHIESA has also selected target crops to feature in the research, namely maize, coffee, avocado and crucifers, all of which are grown at altitudes between 0-2500 meters above sea level, making them ideal for bio-climatic studies.

The purpose of this WP is to increase the knowledge base among the local communities and partner institutions in the three target countries to address climate change issues. Furthermore, research programmes and technologies to assess the risks and impacts of climate and land use change on agro-ecosystems will be initiated and investigated.

chiesa

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

ICIPE

- Dr. Tobias Landmann
- Macharia Kabiro

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).

icipe

IRD Institut de recherche pour le développement

FORMIN.FINLAND.FI MINISTRY FOR FOREIGN AFFAIRS OF FINLAND