# WAGENINGEN UNIVERSITY
## PLANT SCIENCES

# Plant Production Systems Group
## *Leerstoelgroep Plantaardige Productiesystemen*

# Thesis Subjects
## *Afstudeeronderwerpen*

| | |
|---|---|
| Plant Production Systems Group | Leerstoelgroep Plantaardige Productiesystemen |
| Department of Plant Sciences | Departement Plantenwetenschappen |
| Droevendaalsesteeg 1, 6708 PB Wageningen | Droevendaalsesteeg 1, 6708 PB Wageningen |
| P.O. Box 430, 6700 AK Wageningen, The Netherlands | P.B. 430, 6700 AK Wageningen, Nederland |

Plant Production Systems Group
Department of Plant Sciences
Droevendaalsesteeg 1, 6708 PB Wageningen
P.O. Box 430, 6700 AK Wageningen, The Netherlands
Phone:       0317 – 48 21 41 (office)
FAX:        0317 – 48 48 92
Website:     http://www.pps.wur.nl/UK/
Internal mail:  71

Teaching-coordinator: Peter Leffelaar
Phone:       0317 – 48 39 18
E-mail:     Peter.Leffelaar@wur.nl

Leerstoelgroep Plantaardige Productiesystemen
Departement Plantenwetenschappen
Droevendaalsesteeg 1, 6708 PB Wageningen
P.B. 430, 6700 AK Wageningen, Nederland
Tel:        0317 – 48 21 41 (secretariaat)
FAX:        0317 – 48 48 92
Website:     http://www.pps.wur.nl/UK/
Bodenummer:  71

Onderwijscoördinator: Peter Leffelaar
Tel:       0317 – 48 39 18
E-mail:     Peter.Leffelaar@wur.nl

Wageningen, July 2014

# Contents

# Plant Production Systems

The vision of Plant Production Systems is to integrate biological knowledge to analyse and design sustainable production systems for crops (including integration with livestock), focused on resource use efficiency and equitable management of natural resources. Using concepts of systems analysis, we develop methods that allow integrated analysis and design of alternative futures at local (farm), regional, national, international and global scales. We thus contribute to a mission that strives to provide grounded quantitative analysis to underpin responses to urgent societal issues such as global food security, agricultural and environmental policies, competition for natural resources, food-feed-fuel interactions and global environmental change.
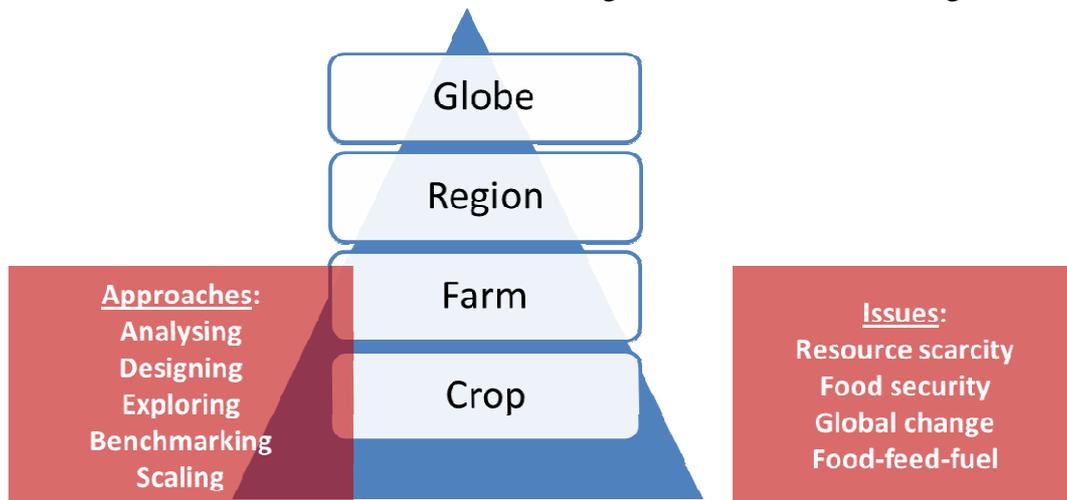


Our research and teaching approach is rooted in the tradition of C.T. de Wit, combining empirical knowledge and production ecological theory with understanding of farming systems derived from surveys and databases. Methodology development and application are central to understanding current systems and design of new production systems that contribute to addressing societal problems of global significance. Various modelling approaches based on simulation of crop and animal production, bio-economic optimization and statistical techniques are key (http://models.pps.wur.nl/). The societal problems require analysis at multiple levels, and a key research issue is scaling from the field to farm, region and the global level. The group also works on analytical and explorative methods to assess the scope for intensifying or improving current systems.
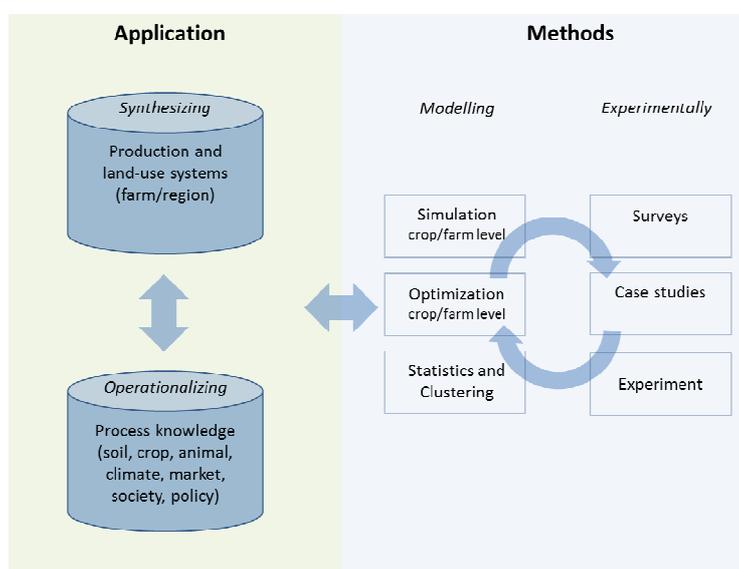
An interdisciplinary approach is central, as the issues deal with complex human systems. With the Animal Production Systems and Biological Farming Systems groups we have established the Wageningen Centre for Agro-ecology and Systems Analysis (http://www.wacasa.wur.nl/). Qualitative analytical social science contributes to scenarios for future studies and examines the role of models in communication and co-learning with stakeholders. Our focus lies firmly in the natural sciences but close collaboration with groups from social sciences (e.g. economics, rural sociology, communication science) furthers integrated assessment methods.

We play a leadership role in developing and executing major collaborative programmes, and disseminating the knowledge generated. Over the past years, our group led three major research projects: SEAMLESS (System for Environmental and Agricultural Modelling; Linking European Science and Society - http://www.seamless-ip.org/ ); NUANCES (Nutrient Use in Animal and Cropping Systems: Efficiencies and Scales - http://www.africanuances.nl/ ) and Competing Claims on Natural Resources (http://www.competingclaims.nl/ ). These projects have delivered concepts and *methods for integrated assessment* of agricultural systems, that continue to play a key role in our research. Major current projects that we lead are:

- N2Africa: putting nitrogen fixation to work for smallholder farmers growing legume crops in Africa http://www.n2africa.org;
- Global Yield Gap and Benchmarking Atlas: developing an Atlas with local relevant information on yield gaps, resource-use efficiencies, including underlying causes, of agricultural systems http://www.yieldgap.org;
- Biomass for fuel: how can feasible options be realised in present farming systems and how can biomass for fuel produced on family farms be attached to the biofuel chain? http://www.foodorfuel.org/.

We also contribute to the following ongoing projects:
- LIAISE: developing an interdisciplinary community of IA researchers and practitioners: http://www.liaise-noe.eu/
- CARE: assessing the effects of climate change and adaptive strategies on agriculture, nature and other land-use functions in the rural landscape of the Netherlands http://knowledgeforclimate.climateresearchnetherlands.nl/climateadaptationforruralareas
- CATCH-C: assessing the farm-compatibility of 'Management Practices' that aim to promote productivity, climate change mitigation, and soil quality: http://www.catch-c.eu/
- Towards sustainable and equitable palm oil (SUS)
- Integrated Management of Rainwater for Crop-Livestock Agroecosystems

A full list of PhD projects can be found on http://www.pps.wur.nl/UK/Staff/.

**Main scientific supervisors**
Prof dr Ken Giller
Prof dr ir Martin van Ittersum
Prof dr ir Meine van Noordwijk
Dr ir Peter Leffelaar
Dr Pytrik Reidsma
Dr ir Katrien Descheemaeker
Dr ir Tom Schut
Dr ir Maja Slingerland
Dr ir Gerrie van de Ven
Ir Joost Wolf
Dr ir Joost van Heerwaarden
Dr ir Linus Franke

**Teaching**

The Plant Production Systems group is responsible for a wide range of courses, from introductory courses to advanced postgraduate specialist subjects. All courses have a modular, flexible set-up and use a variety of teaching methods: lectures, practicals, computer-based tools, discussion groups, etc.. Our BSc and MSc thesis topics usually relate directly to the above-mentioned projects and students are in most cases guided by staff and PhD students.

**COURSES**

The courses in which PPS staff participate are (for periods in which courses can be taken see the Study Handbook of the university):

- *Introduction Plant Sciences* (NEM-10306);
  an introductory course dealing with aspects of crop cultivation, plant breeding and crop protection. Complex agro-ecosystems are analysed and major processes distinguished. These processes are subsequently studied to understand them and to see to what extent they can be managed in order to develop a (more) sustainable agriculture. The leading theme in this course is the effect of various limiting biotic and abiotic factors on the potential production of crops.

- *Introduction to the Life Sciences* (FQD-10306);
  a course that introduces the principles of the natural sciences, taking the various phases of the production chain as guide. After an introduction on agriculture and land use, the principles of plant production are presented. Next, fundamentals of storage, processing, packing, consumption and environmental impact are treated. In close collaboration with the 'Consumer Technology and Product Use' and 'Environmental Systems Analysis' groups.

- *Cropping Systems and Knowledge of Crops* (CSA-10306);
  a descriptive course with several practicals and computer-based tools dealing with the top 100 crops of the world. In close collaboration with the Group Crop and Weed Ecology.

- *Integrated Natural Resource Management in Organic Agriculture* (SOQ-33306);
  this course focuses on the judicious management of natural and human resources for sustainable organic agriculture, involving different agro-ecological regions of the world, different institutional environments and multiple stakeholders and criteria. Emphasis is on the interaction between field – farm and regional scale in a quantitative manner. Attention is given to the contribution of INRM to environmental services, environmental and social impact, conservation of landscape and nature, and animal health and welfare. The course is in close collaboration with other groups.

- *Analysing Sustainability of Farming Systems* (PPS-30806);
  starting with an introduction on farming systems analysis, relevant sustainability indicators are analysed at farm scale relating to crops, cropping systems, grasslands and the interaction with livestock. Insight is gained into: natural agroecological and socio-economic determinants of cropping systems; multiple cropping systems including intercropping, crop rotations and agroforestry; long-term carbon and nutrient balances of agro-ecosystems; soil degradation and its determinants, energy and tillage. The student will use relevant dynamic models and tools for spatial analysis including GIS, to understand the trade-offs and synergies between different farming strategies and land uses.

- *Quantitative Analysis of Land Use Systems (QUALUS)* (PPS-30306);
  an integrative and methodological course dealing with approaches to explore and evaluate future agricultural production and land use systems. Using Multiple Goal Linear programming models, options for land use at farm and regional scale are generated. Each

option depends on emphasis put at a particular land use objective. In close collaboration with many other groups.

- *Crop Ecology* (HPC-21306);
  this course builds on CWE-10304 and PPS-20304 and deepens the knowledge and insight in environmental and crop physiological aspects of crop production, as that takes place both in the field and in the greenhouse, given technological and societal possibilities and objectives. Both experimental and modelling approaches are used together.

- *Quantitative Aspects of Crop Production* (HPC-23303);
  this course is a subset (3 ects) of *Crop Ecology* (HPC-21306). It is meant for our foreign guest students who arrive in September in Wageningen to help them learn the principles of crop ecology early in the year: the full course *Crop Ecology* is scheduled at the end of the academic year (period 5).

- *Models for Ecological Systems* (INF-31806);
  these courses introduce tools to the student that can help judge whether a model is trustworthy or that probably major mistakes occur in the model or in its program code. Such knowledge is often needed in situations where one will use models developed by other people or groups. How to design, build, analyse, and use simulation models forms part of the course. Some complex real world models will be analysed with the tools learned.

- *Sustainable Development: Integrating Worldviews, Disciplines and Practices* (YSD-50306);
  a course dealing with unifying concepts taken from different disciplines and underpinning sustainable development. Theory and practice will be connected through simulations on management of common natural resources, management of a company and effects of policy decisions on people-planet-profit. Students are challenged to reflect on paradigms behind beta and gamma sciences, and on the role of science/scientists, among other things.

- *Systems Analysis, Simulation and Systems Management* (PPS-20306);
  a conceptual and methodical course teaching the principles of systems analysis and simulation, with an emphasis on biophysical and ecological process descriptions. Depending on the specific objective, systems are analysed and captured in quantitative simulation models. Studying model behaviour in comparison to real world behaviour allows testing of hypotheses and increases knowledge.

- *Life Sciences for Communication Scientists* (CPT-34806);
  in this course, social scientists explore the rationality of technical scientists and learn how to interpret their research results. They gain more insight in the role and interaction between life scientists, communication officers, media, policy makers, stakeholders and general public, and reflect upon the societal relevance, risks and ethics of research and communication.

- *Global Food Security* (YSD-50806);
  this course deals with different aspects of food security ((food availability, access, nutritional security), from different angles (history, policy, agronomy, food aid, agrifood chains, GMOs, organic etc.) and different scales (global, national, household, individual). Three weeks of lectures will be complemented by a critical assessment of a movie, by experimental learning when playing a farmer in the africulture game. Based on what you learned you will spend 3 weeks on an assessment of causes of food insecurity in Zambia, judge proposed interventions by FAO on their impact and finally design your own interventions. Students will organise a public debate on food security issues. Apart from generally applicable theory the course focuses on Africa as an area of low food security.

- *Modelling Biological Systems* (EZO-23306);
  in this course first and foremost the reasoning is addressed of how to come from a biological system to a simplified representation: a model. And, what is the biological meaning of parameters in such models. Another important objective is to generate a strong awareness that a theoretical approach should be in balance with an experimental approach to study biological systems. To illustrate all this biological phenomena such as saturation and attenuation, equilibria (including stability and attractors), cycles and chaos, randomness, and pattern formation in ecology are analysed during the course.

- *Introduction Quantitative Agroecology* (CSA-10806);
  this course starts with a debate between two scientists on an actual issue related to Plant Science, e.g. "Are biofuels going to be produced at the expense of food supply to the poor?". This is the starting point for gaining insight in the relevant processes to answer such questions by lectures, self study, group discussions, presentations and written reports. Crop ecological and physiological aspects are connected to plant production at field and farm scale, considering rotations, plant nutrition, plant protection and economic aspects. The course covers theory and facts on agro-ecology in its full scope.

- *Orientation Plant Sciences* (NEM-10806);
  during mini-internships and excursions students will experience the work of a plant scientist as a professional. To further develop insight and skills in the scientific, technological and societal aspects of plant sciences a self-defined project will be carried out. The students will write a scientific report about their project. An additional, major aspect of this course is to obtain knowledge of crops and to recognize the most important crop species and their raw products.

- *Agroforestry* (FEM-22803);
  the concepts and principles of agroforestry systems are introduced using examples from throughout the world. Agroforestry has been transformed from a collection of descriptive studies into more scientific and analytical approaches, based on process-orientated research. A series of lectures and discussions focuses on the ecological processes and environmental interactions that underpin agroforestry. Students work in groups to address key agroforestry hypotheses during this 3 ECTS course.

- *Ecology II* (NCP-20503);
  this course is complementary to and runs parallel to Ecology I (NCP-10503) and consists of a practical and a literature survey. In the practical students use data gathered in the field and the lab to study key ecological principles and processes. The course is completed with a literature survey in which students use scientific literature to answer their own research question.

Furthermore, small contributions are given to the following courses:

-Designing Sustainable Cropping Systems (CSA-32306)
-Seminar Interdisciplinarity in Scientific Research and Education (ESA-32303)
-Agrobiodiversity (SOQ-50806)
-Introduction to Nutrition and Health in Developing Countries (HNE-26806)
-Conservation Agriculture (FTE-50806)
-Grassland Science (CSA-31806)

**Most of the following Master thesis subjects can also be used as basis for a Bachelor thesis. Fieldwork that has to be done abroad, however, will usually be possible only for the MSc thesis.**

# Understanding the yield gap in East African Highland banana in Uganda

**Description**

The Great Lakes Region straddling Rwanda, Burundi, DR Congo and Uganda is characterized by high population densities, with considerable dependence on East African Highland banana (EAHB) production for food and income. The high population densities combined with low EAHB productivity due to water and nutrient stresses dictate that increase in production to meet the demands of the burgeoning populations should be based on intensification approaches. However, the region is in a post-conflict transition with high levels of poverty and poor market access. Furthermore, EAHB response to soil management practices is variable over time and space, necessitating development of pedoclimatic-specific recommendations for optimizing the EAHB cropping systems' productivity. Field studies for generating empirical recommendations based on readily available inputs are costly and lengthy to conduct. Crop growth modelling offers an attractive alternative approach. This study seeks to develop a light interception and utilisation-driven model integrating water-, nitrogen- and potassium-limited EAHB growth simulation. The model will then be used to develop and evaluate EAHB pedoclimatic-specific alternative soil fertility management practices, and the already gathered experimental data will be used to parameterize and validate the model.

The first step in the modelling process has been the development of a potential production model. This model is the starting point for the MSc thesis work to investigate and incorporation water and nutrient stresses.

**Collaboration**

Experimental work may be done at the IITA in Kampala, Uganda.

**Prerequisites**

Several course are relevant such as Modelling Biological Systems, Crop Ecology, Systems Analysis, Simulation and Systems Management.

**Period**

Any time

**Location**

Wageningen and Kampala (Uganda)

**Supervisors**

| | | |
|---|---|---|
| Peter Leffelaar | 0317 – 48 39 18 | peter.leffelaar@wur.nl |
| Ken Giller | 0317 – 48 58 18 | ken.giller@wur.nl |
| Piet van Asten  (IITA) | +256 752 78 78 12 | p.vanasten@cgiar.org |
| Godfrey Taulya (IITA) | | godfrey.taulya@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Modelling the Potential and Water-Limited Yields of Cassava using the LINTUL model

## Description

Cassava is an important staple food crop and source of calories for many people in sub-Saharan Africa (SSA). Cassava yields are poor (10 Mg/ha fresh storage roots in farmer fields against an attainable yield of more than 60 Mg/ha), due to many constraints at plant, field, farm and community and regional levels.

Zooming in at the field level, lots of evidence exists to show that poor soil fertility is the major constraint to crop production in SSA, because most soils are inherently poor, added to the fact that few smallholder farmers use fertilizers in cassava production systems. Poor soil fertility is likely to reduce water and light use efficiency of the crop. Several studies showed that nitrogen and potassium are the most limiting nutrients to cassava production. While nitrogen plays an important role in the vegetative development of the crop and biomass production, potassium is known to be more important in in partitioning of photosynthesis substrates from leaves to stem and storage organs of the crop. Potassium is also known for playing an important role in efficient water use by crops, especially against drought spells. So, in order to formulate proper fertilizer recommendations to replenish the soil in cassava production systems for better resource use efficiency (RUE) and increased productivity of the crop, it is important to understand more how potassium supply affects RUE of cassava.

Several approaches can be used to assess RUE of cassava, including multi-year and multi-location field experiments. Another effective approach is the use of crop growth simulation models. Few of this type of models can simulate K effects on cassava production. CROPSIM cassava simulates cassava growth and development as affected by temperature, photoperiod, intercepted solar radiation, drought, SOC and soil N dynamics, assuming P and K are not limiting, whereas most soils in cassava production areas are depleted in K. The Light Interception and Utilization Simulation model version 5 (LINTUL 5) simulates N dynamics as well as P and K balances. LINTUL 5 can be calibrated for cassava production systems under West Africa conditions. No evidence was found in the literature for the existence of such modelling studies with cassava in the region. However, in order to simulate nutrient limited yield of cassava, the model should be able to effectively simulate the potential and water limited yields of the crop.

A field experiment is on-going for the 2<sup>nd</sup> year to evaluate the effect of potassium on light, water and nutrient use efficiencies of cassava in 2 locations in Togo, West Africa.

We are looking for a hard working MSc student, interested in the use of computer models to:

- Collect field data to assess light, water and nutrients use efficiency of cassava
- Calibrate the LINTUL model for cassava
- Simulate potential and water limited yields of cassava.

## Collaboration

IFDC-Togo (Lomé, Togo) and Plant Production Systems in Wageningen University.

## Location

Sevekpota and Djakakope in Togo, and Wageningen in The Netherlands

## Period

November 2013 to May 2014, with 3 months in the field.

## Supervisors

Guillaume Ezui                                      guillaume.ezui@wur.nl
Linus Franke                                        linus.franke@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Yield improvement of sugar beet and silage maize in the Netherlands

**Description**

Yield increases continue to be of relevance because of economic and food security reasons. This subject studies the progress in yield of sugar beet and/or silage maize in the Netherlands and seeks to disentangle contributions from breeding (Genes – G), environment (Climate – E) and management (M). Contributions from breeding can be studied based on variety trials and appropriate statistical techniques. Effects of climate (change) can be estimated using crop simulation models. Effects on yields not explained by genetic or environmental change are assigned to management. Changes in management can be better understood through analysis of farm yields (statistical data) and interviews. In this thesis you will perform such GxExM analysis for sugar beet or silage maize, in collaboration with experts from applied research stations.

One of the main objectives of this study is to make projections for the future on yield improvement and on closing of the yield gap under a changing climate.

**Collaboration**

Within this MSc-thesis you will work together with the IRS (Institute of Sugar Beet Research in Bergen op Zoom, the Netherlands) or Plant Research International in Lelystad.

**Prerequisites**

Several course are relevant such as Crop Ecology and Systems Analysis, Simulation and Systems Management.

**Period**

Any time

**Location**

Wageningen, Lelystad or Bergen op Zoom

**Supervisors**

| | | |
|---|---|---|
| Martin van Ittersum | 0317 – 48 23 82 | martin.vanittersum@wur.nl |
| Bert Rijk | 0317 – 48 20 56 | hubertus.rijk@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Efficient water use in soilless cultivation of hardy nursery stock plants

**Description**

On sandy soils the water quality standards of the European Union for nitrate are often not met. In order to comply with this legislation development of new cultivation systems is necessary.

For hardy nursery stock the so-called 'U system' has been developed. For a good quality production tailor-made application of water is required. Generally the amount of water applied is based on expert knowledge. It is anticipated that the availability of good quality water will become scarce in the future. Therefore it is important to irrigate accurately.

A model has been developed aiming at an application of as much water as the plants need. In this way also emission of nutrients can be reduced.

This model calculates the water balance based on the interception of light, increase of LAI, evapotranspiration, water lost by drainage and the change in the amount of water in the substrate.

The actual model is based on the data of one species collected during a part of the growing season. Further validation is required.

In 2014 in a follow up study the model will be validated for another species. Unfortunately due to limited time available the study will cover only the first half of the growing season.

It is proposed that also validation takes place for the second half of the growing season so that the full season will be covered. In addition it is proposed that the model is extended with a nitrogen module.

At location Randwijk of WU-Applied Plant Research a U system is available for experiments. Young avenue trees and shrubs are grown in this system from April to the end of October.

**Collaboration**

Wageningen University Plant Production Systems and WU-Applied Plant Research

**Prerequisites**

Preferably a soil physical and crop science background, and a strong interest in modelling: a successful completion of the course Systems Analysis, Simulation and Systems Management and Crop Ecology would be excellent.

**Location**

Randwijk / Wageningen

**Period**

Summer/autumn

**Supervisors**

| | | |
|---|---|---|
| Tom Schut | 0317 – 48 24 54 | tom.schut@wur.nl |
| Henk van Reuler | 0252 – 46 21 13 | henk.vanreuler@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Should climate-driven sowing date rules be soil type specific?

**Description**
Crop yields are dependent on the time when farmers sow their crop. This is not only true for farmers fields, but also outcomes of crop growth models are sensitive to the used sowing date. Therefore, to get realistic estimates of (potential) crop yields from crop growth models, we should know, among others, realistic sowing dates. One strategy could be to ask farmers in the region of interest about their sowing dates. This will be, however, not always possible. Moreover, it can be assumed that farmers will adapt their
sowing dates to changes in climate and therefore current sowing dates will not be valid for future conditions, thus hampering climate change impact studies.

Another strategy to get realistic sowing dates could be developing rules that determine best times for farmers to sow. In regions in which not temperature but mainly water availability is most determining crop yields, e.g. in sub Saharan Africa, sowing of rainfed crops should occur at the beginning rainy season. In this way water availability for the crop will be most optimal. The start of the rainy season varies between years, but in many locations it will occur within a certain fixed time window of approximately one month. A sowing rule for rainfed environments could therefore be: sowing should take place at the first day, within the a priori determined sowing window, on which the cumulative rainfall of the last 3 days is more than 30 mm. The agronomic reasoning is that when this has happened, the soil is wet enough for plants to germinate. Whether this is really true depends however on the characteristics of the soil. Since the soil types of agricultural fields can vary substantially within a region, it is important to know if the sowing date rule should be adjusted per soil type. The aim of this research is therefore to test and implement several sowing date rules for different soil types. In order to do this, a thorough literature study about plant germination and water availability, and the application of a suitable soil water model will be required. With help of a crop growth model the simulated sowing dates can be tested.

**Collaboration**
-

**Prerequisites**
Preferably a soil physical and agronomic background, a strong interest in modelling, A successful completion of the course Systems Analysis, Simulation and Systems Management and Crop Ecology.

**Location**
Wageningen

**Period**
Any time

**Supervisors**

| Lenny van Bussel | 0317 – 48 30 73 | Lenny.vanBussel@wur.nl |
| Martin van Ittersum | 0317 – 48 23 82 | Martin.vanIttersum@wur.nl |
| Joost Wolf | 0317 – 48 30 78 | Joost.Wolf@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Modelling the geographic distribution of crop yields and response to inputs in tropical smallholder systems

**Description**

The challenge of providing food security for a growing population has generated strong interest in the determinants of differences in yield and yield potential, particularly in tropical smallholder systems. Recent yield gap analysis in small scale farming systems suggests that responses to fertilizers or other inputs are affected by local soil constraints. Yield responses to fertilizer thus seem to be greater for better soils, i.e. soils that yield more in the absence of inputs. This suggests that investment in inputs may not be worthwhile for some of the poorest farmers living on poorer soils, leading to a poverty trap (Tittonell and Giller, 2013).

Although some of the yield limiting factors have been identified, they seem to explain relatively little of the variation in observed yields, resulting in what can be called a "missing yield" problem. This problem may be caused by both a lack of sufficient information on biophysical and management constraints and by difficulties to properly model actual yields under limiting conditions. Potential solutions may therefore lie in exploiting modern tools like geospatial modelling using available geospatial datasets (derived from e.g. remote sensing) to increase the amount and usefulness of biophysical data, or in the creation of improved crop models to predict yield under limiting conditions.

The aim of this research project is to better understand the observed distribution of yields and yield responses to fertilizers. The influence of variation in biophysical characteristics on yields within a given spatial context will be evaluated with spatial crop growth models. The empirical basis for the research will be a large set of on-farm input trials implemented as part of PPS' N2Africa project. The basic approach will be as follows:

- Parameterise a field-level crop growth model to simulate yield under different levels of availability of water and nutrients.
- Determine the spatial distribution of the values of the model parameters, by combining different sources of remote sensing and soil data.
- Produce spatially explicit model predictions to determine the geographic distribution of differences in yield and yield response.
- Compare the simulated patterns to those observed in the experimental data.

**Collaboration**

The project uses a diverse set of quantitative approaches involving input from PPS researchers with expertise in crop growth modelling, remote sensing/GIS and statistics.

**Prerequisites**

A background in plant or soil science with strong interest in quantitative research and modelling. Successful completion of the following courses: Advanced Statistics, Systems Analysis, Simulation and Systems Management.

**Location**

Wageningen

**Period**

Any time

*Reference*
Tittonell P, Giller KE (2013) When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. *Field Crops Research,* **143**, 76-90.

**Supervisors**

| | | |
|---|---|---|
| Joost van Heerwaarden | 0317 – 48 69 40 | joost.vanheerwaarden@wur.nl |
| Tom Schut | 0317 – 48 24 54 | tom.schut@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Yield gap analysis for oil palm production in Indonesia

**Description**

Oil palm production for biofuels is receiving much publicity – though generally negative. This is often associated with an assumption that the expansion of the area under oil palm occurs at the expense of tropical rainforest. Conversely, oil palm is a very efficient crop for vegetable oil production and if managed properly one of the most attractive sources of biofuels. Present yields of oil palm plantations are far below their theoretical potential due to imperfect management. Yield intensification would make area expansion unnecessary. There is also great potential to expand oil palm production into vast areas of degraded anthropic (human-induced) savanna lands.

In this thesis you will quantify the yield gap of oil palm production in Kalimantan, Indonesia. You will assess the difference between what is currently produced and what the soil-climate combinations in this region would allow under different management strategies. You will display the land suitability and yield gap in maps and verify results with experts.

**Collaboration**

The research will be conducted in collaboration with private companies and research institutes in south-east Asia.

**Prerequisites**

Background in forestry or plant sciences with a strong interest in quantitative analysis. Skills in GIS will be an advantage. Successful completion of the course Quantitative Analysis of Croppping and Grassland Systems, Systems Analysis, Simulation and Systems Management or Models in Forest and Nature Conservation.

**Location**

Wageningen

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Lotte Woittiez | 0317 – 48 21 41 | lotte.woittiez@wur.nl |
| Ken Giller | 0317 – 48 58 18 | Ken.giller@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Effects of phosphorus limitation on global food security

**Description**
Phosphate deficiency limits crop production in most parts of the world especially in poor countries (e.g. African countries) where fertilizers are unaffordable. On the other hand in some countries large amounts of applied fertilizer in the past cause an environmental pollution. As rock phosphate is the only available source of phosphate, production of phosphorus (P)-fertilizer, laundry and dishwasher detergents, feed P supplements and industrial applications may rapidly deplete the currently known P resource. Agriculture is the largest global consumer of phosphate and the price of P fertilizer has more than doubled in the past three years. Phosphate is likely to be a key factor limiting future food availability. At current rate of use, the known reserves will last only 50-100 years. The threat of P resource depletion and associated effects on fertilizer prices is definitely an essential reason to increase the efficiency of P use in agriculture. The final objective of this research is to assess the demand for phosphate (P) fertilizer in alternative global food production scenarios and possible consequences of P shortage for different regions of the world. Using available models such as the QUEFTS model, we can investigate impacts of variation of P on the target yield and food production. To tackle this problem, following research topics could be covered:

(i)     Applying the QUEFTS model to a temperate or tropical region to test relationships between P fertilization and productivity and compare these with observations.
(ii)    Measuring and modelling nutrient requirements (N, P, K) for different crops and different soils.
(iii)   Designing an assessment for staple food production in the world (based on a categorization of crop types, climate and soil types).
(iv)    Designing an audit on data collection and analysis of soil P status at global scale.

**Collaboration**
Joint subjects with other groups from e.g. Plant and Environmental Sciences can be discussed.

**Prerequisites**
Several courses are relevant such as Crop Ecology, Soil fertility and Nutrient management (SOQ-310806). Strong interest in modelling and data analyses is desired.

**Period**
Any time

**Location**
Wageningen

**Supervisors**

| | | |
|---|---|---|
| Martin van Ittersum | 0317 – 48 23 82 | Martin.VanIttersum@wur.nl |
| Ken Giller | 0317 – 48 58 18 | Ken.giller@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# What is the influence of sowing date on the time to flowering in cover crops?

**Description**

Cover crops form an increasingly important part of European arable cropping systems. Their main advantages are reduction of nitrate leaching, replenishment of soil organic matter and suppression of soil-borne pathogens. For a cover crop to be successful, it is ideally grown after a main crop and will not reach flowering stage. Farmers are reluctant to grow cover crops that set seed, for the seeds can become weeds in the next season. Two of the main crops that are used as cover crop in Europe are White mustard (*Sinapis alba*) and Oilseed radish (*Raphanus sativus* var. *oleiformis*). A large number of varieties have been developed of these two species, differing in, among other characteristics, flowering date. As the same varieties are grown from Scandinavia to the Mediterranean countries and sowing can occur between July and October, estimation of flowering time in relation to sowing date is important. Flowering time in cruciferous crops is determined by a combination of day-length and temperature sum.

The aim of this research is to develop a model that can explain varietal differences in time to flowering found in a set of sowing date experiments. With the model we aim to improve our selection strategy to select more efficiently for desirable genotypes. A next goal is that such a model can be used to predict flowering time given sowing date and specific location across Europe, based on climate data.

A set of experimental data has been collected and can be used as basis for this research. The experiments consist of different varieties that were sown with one month interval, with their phenology noted. The experiment was carried out over two years. A large number of other varietal trials are available to calibrate and validate the model.

Besides the development of theory, experiments may be proposed to test the theory. If there is enough time such experiments can be executed. Next to the scientific question, the student will learn how scientific knowledge is applied in a commercial plant breeding program.

**Collaboration**

With the breeding department of the seed company Joordens Zaden.

**Location**

Wageningen/Neer (L)

**Period**

Any time

**Supervisors**

Peter Leffelaar          0317 – 48 39 18          peter.leffelaar@wur.nl

Michiel de Vries                                michielerikdevries@gmail.com

**General information:** Teaching-coordinator (see first page of booklet)

# Assessing soil fertility constraints to improve return on smallholder investments

## Description
It has long been recognized that nutrients are the major constraint for production of sub-Sahara ecosystems (Breman and De Wit, 1983). West-African smallholder farming systems use only a limited amount of fertilizer inputs, while crops are often nutrient deficient. Low biomass productivity further enhances soil degradation. Techniques to intensify farming systems sustainably, such as conservation agriculture must include appropriate use of fertilizer (Vanlauwe et al., 2014). However, responses to fertilizer on poor soils are often uncertain (Tittonell and Giller, 2013), and uncertainty about financial returns to fertilizer or soil fertility treatments may limit smallholder investments in external inputs, resulting in further soil fertility and yield declines.

Yield gaps are defined as the difference between potential and actual yields and can be caused by water, nutrient availability, biotic stress or crop management factors (see Van Ittersum and Cassman, 2013 and references therein). To improve yields most effectively, it is important to know the relative importance of each of these factors. The concept of comparisons crop responses with in-field mini-plots, i.e. fertilizer soil fertility treatment windows, has been used for assisting fertilizer applications in wheat and potato crops (van Evert et al. 2012). A direct comparison between crop growth in fields with these windows allows to quantify the importance of nutrient constraints on growth. Hence, we hypothesise that these comparisons reduce uncertainty in financial return. Secondly, local fertilizer windows provide a better understanding of local soil fertility constraints and hence may strongly contribute to the improvement of the accuracy of crop growth models in dryland systems.

In this project, you will:
-assist in collection of field data from cropping systems near Koutiala (2014 or 2015) in southern Mali or near Kanu (2015) in northern Nigeria;
-evaluate differences in fertilizer response curves across crops and fields;
-evaluate the importance of nutrient limitations on growth of major crop types in the region;
-assess accuracy of a selected crop growth model (e.g. DSSAT/APSIM/LINTUL3) including effects of macro-nutrient deficiency.

## Collaboration
Fieldwork in Mali or Nigeria will be conducted in collaboration with our partners including, amongst others, ICRISAT, AMEDD and IER. For Mali, a basic understanding of French is strongly desired. Financial assistance for travel is available.

## Prerequisite
Students with an interest in plant production systems and crop growth modelling.

## Location
Field work to be done in Mali or Nigeria and data analysis in Wageningen. Field data will be collected in collaboration with others within a larger project looking at land information and crop type recognition with remote sensing. To this end, information on soil conditions and management practises will be collected and crop growth and plant stress will be monitored during the 2014 and 2015 growing season in 50 smallholder fields including 5 major crop types in both Mali and Nigeria. You will work within a team of local experts and technicians. The project offers excellent opportunities to work with smallholder farmers.

## Period
Growing season (May-October) in 2014 or 2015

*References*
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Jongschaap, R. E. E. and R. Booij (2004). Int. J. Appl. Earth Obs. 5: 205-218.
Vanlauwe et al. (2014). Field Crops Res. 155: 10-13.
van Ittersum, M. K. and K. G. Cassman (2013). Field Crops Res. 143(0): 1-3.

Evert, F. K. van, R. Booij, et al. (2012). Eur. J. Agron. 43: 58-67.
Tittonell, P. and K. E. Giller (2013). Field Crops Res. 143(0): 76-90.
Shibu, M. E., P. A. Leffelaar, et al. (2010). Eur. J. Agron. 32(4): 255-271.

**Supervisors**
Tom Schut                          0317 – 482454          tom.schut@wur.nl
Katrien Descheemaeker    0317 – 486102          katrien.descheemaeker@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Quantifying nutrient deficiency and crop variability in smallholder fields

**Description**

West-African smallholder farming systems use only a limited amount of fertilizer inputs, while crops are often nutrient deficient. In the dry sub-Sahara landscapes, effective conservation agriculture must include appropriate use of fertilizer as production is more often nutrient than water limited. However, yield responses to fertilizer on poor soils are often uncertain. Accurate indications of financial return to fertilizer application or soil fertility treatments are limiting smallholder investments in external inputs. In-season canopy reflection measurements have successfully been used to quantify nutrient stress in European cropping systems and assist in nutrient application. Modern mobile telephone networks are well developed and truly provide information services to smallholder farmers ([http://www.manobi.sn/sites/za/](http://www.manobi.sn/sites/za/)). With the advancements of high resolution satellite imagery, crop type recognition and in-season response monitoring in these smallholder farming systems becomes an option, and may be integrated in mobile information services.

Imagery data from small plots within farm fields with different fertility treatments or fertilizer applications may assist in a better understanding local fertilizer responses. The objectives in this thesis work are to 1) quantify the potential yield gains when fertilizer is applied under local soil conditions and management, and 2) evaluate if and how nutrient stress can be quantified with high-resolution imagery. To this end, field variability in plant density, light interception and plant nutrient stress will be measured in the field. Fields will be compared with these small plots using high resolution images collected with a small, remote controlled aircraft, so-called Unmanned Aerial Vehicles (UAV) or quadcopters.

**Collaboration**

You will work within a team of local experts and technicians to collect field data and develop algorithms to quantify within-field variation of nutrient deficiency. Measurements will be carried out in collaboration with ICRISAT and local partners in existing experiments on smallholder farms including 5 major crop types where UAV imagery is collected at regular intervals during the growing season.

**Prerequisites**

Preferably a soil physical and biological background, a strong interest in remote sensing. A successful completion of the course Systems Analysis, Simulation and Systems Management. A good command of the French language is strongly preferred when working in Mali.

**Location**

Wageningen and Kano (Nigeria) or Koutiala (Mali)

**Period**

Between April and November

**Supervisors**

| | | |
|---|---|---|
| Tom Schut | 0317 – 482454 | [tom.schut@wur.nl](mailto:tom.schut@wur.nl) |
| Lammert Kooistra | 0317 – 481604 | [lammert.kooistra@wur.nl](mailto:lammert.kooistra@wur.nl) |

**General information:** Teaching-coordinator (see first page of booklet)

# N2Africa – Putting nitrogen fixation to work for smallholder farmers in Africa

**Description**

N2Africa is a large scale, development to research project focused on increasing inputs from biological nitrogen fixation (BNF) by grain and fodder legumes among smallholders in sub-Saharan Africa. Net soil nitrogen accrual from the incorporation of grain legume residue in Africa can be as much as 140 kg N ha$^{-1}$ depending on the legume type and variety. This N tends to be released quickly when legume residues are incorporated into the soil and can contribute to substantial improvements in yield of subsequent crops. Grain legumes are also a key source of nitrogen-rich edible seeds, providing a wide variety of high-protein products and constituting the major source of dietary protein in the diets of the poor in most parts of sub-Saharan Africa. Legumes such as groundnut and soybean are also major sources of edible oil and other industrial by-products. In addition, residues of grain legumes as well as herbaceous and fodder tree legumes provide an excellent source of high quality feed to livestock especially during dry seasons when animal feeds are in short supply.

Successful BNF by legumes in the field depends on the interaction:
$(G_L \times G_R) \times E \times M$
(Legume genotype $\times$ Rhizobium strain) $\times$ Environment $\times$ Management
where environment encompasses climate (temperature, rainfall, day length etc to encompass length of growing season) and soils (acidity, aluminum toxicity, limiting nutrients etc). Management includes aspects of agronomic management (use of mineral fertilizers, sowing dates, plant density, weeding). Incidence of diseases and pests are also a function of $(G_L \times G_R) \times E \times M$. Thus establishment of effective BNF depends on optimizing all of these components together. Legumes are often women's crops, grown for home consumption and they are thus often grown in poorer soils with little application of manure. They are also allocated less attention in terms of labor for crop management. This means that E and M often override the potential of the legume/rhizobium symbiosis for BNF. Understanding these interactions, how these are affected by constraints at a farm or farming system level and what this means for the ability of different farmers to adopt legume technologies are key in the research activities of this project.

Various research topics can be addressed through a thesis within the framework of N2Africa:
- Research on legume varieties, inputs, intercropping, crop rotations, and non-responsive soils with the objective of understanding the variability in responses of legumes to inputs and rotational effects of legumes at a field level
- Characterisation of farming systems and studies of adoption processes with the aim to identify socio-ecological niches for legume technologies among different types of farmers
- Farm simulation modeling to assess current farming systems and explore scenarios with an increased adoption of legume technologies impacting households' food self sufficiency and ability to generate cash income

**Collaboration**

N2Africa is led by Wageningen University together with CIAT-TSBF, IITA and has many partners in the Democratic Republic of Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda and Zimbabwe. Currently, new partnerships are established in Ethiopia, Uganda, Tanzania, Liberia and Sierra Leone.

**Location**

Wageningen and various African countries.

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Ken Giller | 0317 – 48 55 78 | ken.giller@wur.nl |
| Linus Franke | 0317 – 48 13 76 | linus.franke@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Adaptation to climate change and other drivers of change in livestock systems of southern and West Africa

**Description**

Rangelands are an important component in crop-livestock, and livestock-based farming systems in vast areas of Africa. The productivity of rangeland systems is the result of the interaction between climate and intensity and history of land use. Because rangelands are not only important for livestock keepers but also for ecosystem services we are interested in understanding how people interact with the natural resource and the trajectory of change under future more variable environment. This understanding needs to be included in models to explore directions of development of the rangelands under different scenarios of climate change and adaptation. We are looking for students that want to combine field work, observations, interview herdsman and summarize the information in an explorative modelling framework. Because the topics can be addressed from different points of view, we encourage students with backgrounds in social and natural sciences to contact us to discuss possibilities for applying interdisciplinary approaches.

The aims of this project are to quantify the effect of climate and management on rangelands productivity, and the relative contribution to the livelihood of farmers and pastoralists.

We address in this project two major questions:
1. What are the trajectories of change and feasible solutions that reconcile the competing claims of pastoralists for rangeland and other feed resources?
2. How could intensification of livestock systems substitute for mobility and reduce the stress on the environment and the risks on livelihoods of pastoralists?

**Collaboration**

In case of field work, this will be done in Africa with local support of the International Livestock Research Institute (ILRI), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

**Prerequisites**

Completion of the courses Systems Analysis, Simulation and Systems Management and Analysing Sustainability of Farming Systems.

**Location**

Africa: Zimbabwe or Mali.

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Katrien Descheemaeker | 0317 – 48 61 02 | katrien.descheemaeker@wur.nl |
| Mary Ollenburger (Mali) (WUR) | | mollenburger@gmail.com |
| Patricia Masikati (Zimbabwe) (ICRISAT) | | p.masikati@cgiar.org |

**General information:** Teaching-coordinator (see first page of booklet)

## Co-learning with farmers in the African context: how do we communicate model results?

**Description**

Scientific models are useful tools to extrapolate and add value to experimental and observational data and to understand system constraints and opportunities. Models can be used to conduct "What if?" analyses, generating information that could be used by farmers, extension agents and policy makers to guide them in strategic, operational and tactical decision making. However, in practice, the use of models as decision support tools is often not as common as anticipated. Also, because models are built and used mostly by researchers, the model outputs are not always meaningful or understandable for farmers. Especially in developing countries where farmers are often not well educated or even illiterate, this is a challenge.

This research therefore aims to find ways to bridge the gap between modelers and farmers by looking for common ground and visualization methods through which effective communication can be facilitated. Understanding farmers' mental model of their farming system is a key element in this. Outputs of the research could include:

1. A specific problem that can be studied through modeling is identified and described together with farmers, and potential solutions are put forward
2. Farmers describe the farming system, including its boundaries, components, interactions and resource flows between components
3. Researchers build a dynamic model based on the description of the system and simulate the effect of potential solutions
4. The effects of potential solutions are communicated to and discussed with the farmers through various techniques. The effectiveness of the different techniques is evaluated based on a set of criteria
5. The model is adjusted based on the discussions and point 4 and 5 are repeated.
6. Along the way learning by farmers and by researchers is captured

The research questions are as much in how we capture learning and how we evaluate the effectiveness of communication techniques, as in the development of the model and the communication techniques themselves.

**Collaboration**

Fieldwork with farmers will be conducted in mixed crop-livestock farming systems in West Africa (Ghana, Burkina Faso or Mali). Depending on the site, collaboration will be with ICRISAT or ILRI and with a local agricultural research institute.

**Prerequisites**

Creative student with a strong interest in modelling, communication tools and social interactions.

**Location**

Northern Ghana/Burkina Faso/Mali and Wageningen.

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Katrien Descheemaeker | 0317 – 48 61 02 | katrien.descheemaeker@wur.nl |
| Annemarie van Paassen | 0317 – 48 22 58 | Annemarie.vanpaassen@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Innovative Business Model on High Value Crops in a Farmers' based Crop Rotation in Ethiopia

**Description**

*Project purpose*

The purpose of the project is to design, implement and promote an innovative business model that enables Ethiopian smallholder farmers to transform their farms into cooperating food-producing enterprises, embedded in a vital network of input supply, mechanization, knowledge, finance facilities and sustainable food markets.

The concept of a balanced crop rotation for sustainable and diversified outdoor farming will be the foundation of the project. Producer groups of farmers will be trained and coached in the proper crop production, farm economics and marketing strategies, embedded in the standards of Good Agricultural Practices.

The implementation of the business model in three complementary agro-ecological zones meets the market demand of continuous supply of quality food during all seasons and thus enables food producers to establish permanent links with market partners. Application and fine-tuning of the business model to 11,250 small-scale farms in three regions furthermore provides the sound scientific data to publish the detailed framework of the developed innovative business model and to disseminate the successful model towards other sectors, regions and countries. As a spin-off of this private sector development approach, the initiative will contribute to the year-round access of the Ethiopian people to a diversity of healthy food products produced by their own farmers.

*The role of Wageningen University*

The role of Wageningen University in this project is monitoring and evaluation of the effects of project interventions on farm performance, household food security and on farmers capacity to access inputs, credit, mechanisation and markets through collective action (farmer groups). Monitoring farmers' agronomic performance is an essential part underpinning the project outcomes. Wageningen University is also responsible for scientific publications. An Ethiopian PhD researcher, supervised by PPS and MST will be doing most of the work. Given the complexity of the project and the fact that it is dispersed over three locations, MSc students are very welcome to do part of the work through tailor made research topics.

*Research topics*

During project implementation many research topics will come to the fore in different fields of science. All kind of questions will arise around crop rotations. For instance how does crop rotation affect soil fertility management. What sequence of crop rotation is best in relation to soil tillage needs, prevention of weeds and diseases, soil fertility management?

Other questions will relate to household food security. How does entrance into the project affect farmer households food security. How does entrance in the project affect allocation of land and labour and of the benefits of cropping between men and women?

The project also opens opportunities for comparison of the three different agro-ecological zones regarding crop performance.

**Collaboration**

Solagrow PLC-Ethiopia (A Dutch potato grower); SNV-Ethiopia; Terrafina Microfinance and Wageningen University (Plant Production Systems group and Management Studies group).

In case of experiments with the Group Agro-technics and Physics of the Wageningen University.

**Location**

Central and Northern Ethiopia (Shoa, Arsi and Gojam)

**Period**

First MSc topics to start in April 2014

**Supervisors**

Maja A. Slingerland (contact)           0317 – 48 35 12           maja.slingerland@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Integrating Farm Components for Enhanced Productivity and Sustainability of Homegarden Agroforestry Systems in Southern Ethiopia

## Description

Perennial-crop based homegardens where enset and coffee crops are combined have sustainably fed about 20% of the population residing in the southern highlands of Ethiopia for centuries. Enset is the major staple food source of the households and plays an important role in the food security of the region. Besides being a food source, enset is also a major source of livestock feed and a means of minimizing soil erosion and runoff, thus improving the water and nutrient budget of the system. Coffee provides the principal source of cash income and its processing and marketing creates employment for a large number of people. A wide variety of systems exists depending on the local conditions. Notwithstanding claims that homegardens are sustainable systems thanks to their large diversity and extensive system component interactions, quantitative analyses of the indicators that could elucidate sustainability are scarce.

Increasing commercialization and land pressure have led to the gradual replacement of this age-old diversified system by mono-cropping systems of maize (food crop), khat and pineapple (cash crops) with a whole set of related problems.

This research is part of a PhD project that analyses the historical dynamics, productivity and resource use efficiency and explores sustainable alternative management options for the improvement of homegardens in southern Ethiopia.

Research that can be part of the MSc thesis includes
- Identify the main drivers for the transition of traditional homegarden agroforestry systems to commercial mono-cropping oriented systems and assess how the systems are evolving
- Quantify productivity and input/ouput flows of different homegarden systems, both traditional and newly emerged ones
- Field experiments on different intercropping systems (maize-trees; maize-beans; khat-elephantsgrass)
- Assessing the sustainability of homegarden agroforstry systems using a number of criteria related to economic, ecological and social factors

These are examples, but also other topics within the PhD framework can be addressed.

Field work the Sidama zone is part of the Msc.

## Collaboration

Hawassa University, Hawassa, Ethiopia

## Location

Hawassa (Sidama Zone) and Wageningen

## Period

Any time, but field experiments from Jan 2014 onwards

## Supervisors

| | | |
|---|---|---|
| Beyene Teklu Melisse | | beyene.mellisse@wur.nl |
| Gerrie van de Ven | 0317 – 48 21 40 | Gerrie.vandeVen@wur.nl |
| Katrien Descheemaeker | 0317 – 48 61 02 | katrien.descheemaeker@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Ecological intensification of mixed crop-livestock systems in Southern Mali

## Description

The cotton zone of Mali is characterized by high population pressure, and farmers currently rely largely on cotton and livestock for income and on sorghum and millet as staple food crops. Crop-livestock interactions are a key element of these farming systems, accounting for good cotton and cereal yields, food self-sufficiency and income generation. However, the region has faced a vicious cycle of land degradation and decreasing soil fertility, leading to decreasing yields in recent years. We propose to develop and apply a framework to understand these crop-livestock farming systems, their components and interactions. We will test the hypothesis that ecological intensification, consisting of the integrated and judicious use of fertilizer, improved varieties of dual purpose legumes, stable feeding and improved manure management will improve farmers' livelihoods. Simulation models can help us analyse complex interactions in mixed farming systems, and evaluate the potential effect of technologies. However, simulation modelling can only be relevant for farmers if done in conjunction and with continuous feedbacks to and from on-farm participatory testing and evaluation of promising technologies.

As part of this project, students can focus on one or more of the below topics:

1. Assessment of the effects of various intensification options on whole farm resource use efficiency, farm production risk and farmers' resilience for different farm types, drawing on on-farm experiments and/or modeling results
2. Production gap analysis in both crop and livestock components of the mixed farming systems. This builds on a comparison of potential with actual production levels and includes identifying the major biophysical and socio-economic constraints causing the production gaps, and analyzing to what extent ecological intensification could close the production gaps.
3. Livestock feed supply and demand analysis, taking into account transhumance practices, which are common in the regions

Different methodologies can be applied and combined, including field measurements of crop, fodder biomass and livestock production and water and nutrient flows, household surveys and group discussions, and simulation modeling.

## Collaboration

Fieldwork in Southern Mali will be conducted in collaboration with our partners ICRISAT and IER. Local supervision will be done by PhD students Gatien Falconnier and Mary Ollenburger.

## Prerequisite

Students with an interest in interdisciplinary work and systems analysis.

## Location/time

Mali and Wageningen. Students interested in getting involved in the agronomic trials need to plan to be in the region during the growing season (June-October). Others are less restricted in terms of time.

## Supervisors

Katrien Descheemaeker            0317 – 48 61 02        katrien.descheemaeker@wur.nl
Gatien Falconnier (ICRISAT/WUR)                          falconniergatien@yahoo.fr
Mary Ollenburger (WUR)                                   mollenburger@gmail.com

**General information:** Teaching-coordinator (see first page of booklet)

# Climate change impact and adaptation options in smallholder mixed crop livestock systems

**Description**

Mixed crop-livestock systems in Africa support the majority of rural and urban livelihoods and contribute significantly to food security. These farming systems are affected by climate change through impacts on feed quantity and quality, through changes in crop production and composition, and through changes in rangeland production and their species composition. Climate change intricately affects the spread and incidence of livestock diseases, and more directly, increasing temperature affects livestock performance. Whereas animals are in general less vulnerable to drought than crops, extreme droughts can wipe out regional or national herds, which take a long time to recover. The high diversity of farming systems both across agro-ecological zones and within communities, coupled with the variety of and uncertainty around climate change trends, make generalized conclusions on the most promising adaptation options difficult. Moreover, in many places, other drivers such as population increase, urbanization, changing policy and institutional contexts, and expanding markets exert a stronger, more immediate influence on smallholder systems than climate change.

In this project climate, crop and livestock modelling is combined with economic assessments of the effects of climate change and adaptation. This is done based on detailed data collected through surveys and crop and livestock experiments.

As part of this project, students can focus on one or more of the below topics:

1. Calibration and evaluation of a rangeland model, including simulations of future climate change effects on biomass quantity and quality
2. Detailed comparative analysis of adaptation options to livestock and crop production components
3. Analysis of between-farm variability in terms of climate change and adaptation impacts on various aspects of livelihoods.

The research will focus on modelling, with possibilities for complementary data collection in Mali or Zimbabwe.

**Collaboration**

In case of field work, this will be done in Africa with local support of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

**Prerequisites**

Students with an interest in interdisciplinary work, modelling and systems analysis. Completion of the courses Systems Analysis, Simulation and Systems Management and Measuring Sustainability of Farming Systems.

**Location**

Wageningen and Africa: Zimbabwe or Mali

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Katrien Descheemaeker | 0317 – 48 61 02 | katrien.descheemaeker@wur.nl |
| Mary Ollenburger (WUR) | | mollenburger@gmail.com |
| Patricia Masikati (ICRISAT) | | p.masikati@cgiar.org |

**General information:** Teaching-coordinator (see first page of booklet)

# Changes in coffee-based farming systems: farmers' decision-making and socio-economic trade-offs in Uganda

## Description

This project will be hosted by the International Institute of Tropical Agriculture (IITA) in Uganda working on coffee quality, different coffee-cropping systems and coffee management practices both from an agronomic as from a socio-economic point of view.

The thesis opportunity which we offer is embedded within a PhD research on coffee-based farming systems. One of the research questions is around changes in these coffee-based systems over time and the local socio-economic trade-offs. We conduct research in the central and eastern region of Uganda. We are most interested in understanding farmers' behaviour concerning cropping choice, specific cropping system (mono/inter-cropping) and management practices. On Mount Elgon there is also an aspect of climate change threatening the production of coffee, as temperature is expected to increase.

The work would involve data collection on the individual farming systems: inventory of all the crops, the resource use and distribution at the farm, and changes within these systems over the years. Concerning the changes we are interested in the trade-offs between allocation of resources (inputs and labour), the factors influencing decision-making concerning changes in the farming systems and the livelihood outcomes of these farming systems in terms of food availability, income and sustainability. This research will require in-depth interviews in the field with the farmers. Specific measurements at farm-level concerning soil status, environmental climate etc. can also be done.

Specific focus around/within this topic can be adapted to your personal preferences.

We would preferably have two students working together but in different regions of Uganda. At IITA we can offer accommodation, an office and team in Uganda and cover the costs of fieldwork. Other costs are for the student.

## Collaboration

International Institute of Tropical Agriculture (IITA)

## Prerequisites

- Interest in understanding farming systems from a social point of view, i.e. why do farmers actually do what they do?
- Experience with social field research (structured and semi-structured interviews, participatory rural appraisal).

## Location

Kampala and rural areas in Uganda.

## Supervisors

| | | | |
|---|---|---|---|
| Wageningen: | Ken Giller | 0317 – 48 55 78 | ken.giller@wur.nl |
| | Gerrie van de Ven | 0317 – 48 21 40 | Gerrie.vandeVen@wur.nl |
| Locally: | Piet van Asten | +256 752 78 78 12 | p.vanasten@cgiar.org |

**General information:** Teaching-coordinator (see first page of booklet)

# Characterization of farming systems and livelihoods of farm households for yield gap analysis in developing countries

## Description
Sustainable intensification is regarded as an appropriate strategy for increasing agricultural production while at the same time reducing environmental impacts. It is based on the following three principles: 1) closing existing yield gaps, 2) maintaining or improving soil quality and 3) increasing resource use efficiency through precision farming. Yield gaps may be defined as the difference between a benchmark yield (e.g. potential or water-limited) and an actual yield obtained in farmers' fields.

So far, yield gaps have been assessed at field or regional levels. Such scales of analysis may not be the most appropriate to understand and explain existing yield gaps and to provide recommendations for their closure, because they do not take into account farmers' decisions. It is then necessary to perform yield gap analysis from a farming system perspective, i.e. considering the management strategy adopted, the current farm characteristics and other livelihood, socio-economic and institutional factors.

A farming system can be fully described in quantitative terms by its technical coefficients, also called input-output combinations. This corresponds to the first step of a yield gap analysis at farm level and requires extensive and good quality data for a set of individual farms. Available datasets tend to be coarse and incomplete as data of individual farms is often unavailable, and management (and other socio-economic) information is usually not considered, hence leading to unreliable outcomes.

The objective of this MSc study is to collect and analyze farm level information for 1) the quantitative estimation of technical coefficients and 2) the socio-economic characterization of farming systems in a specific region of Southeast Asia or Sub-Saharan Africa. This study is part of the PhD project "From diagnosis to design: Explaining yield gaps and resource use efficiencies at farm and farming system level to explore options for sustainable intensification". The MSc and PhD student will closely collaborate.

## Collaboration
Mapping for Sustainable Intensification (http://www.wageningenur.nl/en/About-Wageningen-UR/Strategic-plan/Sustainable-and-Smart-Food-Supply-BASIS.htm), N2Africa (www.N2Africa.org) and Global Yield Gap Atlas (www.yieldgap.org)

## Location
Region in Southeast Asia or Sub-Saharan Africa

## Period
Any time

## Supervisors
| | | |
|---|---|---|
| Pytrik Reidsma | 0317 – 48 55 78 | pytrik.reidsma@wur.nl |
| João Vasco | | joao.silva@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Unravelling the yield gap in Africa using large databases

**Description**

Raising agricultural yield in Africa is a priority both from a poverty and a food security perspective. LEI-WUR and Plant Production Systems (PPS) are working on a multi-year project to assess global yield gaps. The aim of the project is to investigate the sources of yield gaps in Africa both from a socio-economic and agronomic perspective. A new framework will be developed and tested to combine socio-economic and agronomic determinants of yield gaps. As part of the project a new database will have to be constructed that combines data from the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) and the Global Yield Gap project (www.globalyieldgap.org). The new dataset will be used to investigate the impact of a large number of socio-economic and agronomic determinants on yield and the yield gap using exploratory analysis (tables and graphs) and econometric techniques. The project has a focus on Ghana and Ethiopia but it is also possible to select one of the other African countries for which data is available (e.g. Nigeria and Uganda). All the analysis for the project is expected to be done with the open source software R for which training will be arranged. R is a multi-purpose data processing and statistical platform, which use is rapidly growing in academics and business. For more information see: http://www.r-project.org and for interesting applications see: http://www.r-bloggers.com. The project is funded by DFID and the WUR.

**Collaboration**

The project is a collaboration between LEI-WUR and PPS.

**Prerequisites**

Interest in yield gap analysis from an economic and agronomic. Experience with (light) programming in packages such as Stata, R, SPSS, GAMS, etc. and an interest to learn to use and code in R. Experience with statistical analyses as shown by completion of (advanced) econometrics/statistics course. Preferably successful completion of QUALUS.

**Location**

The Hague

**Period**

4-6 months in the period September 2014-June 2015.

**Supervisors**

| | | |
|---|---|---|
| Pytrik Reidsma | 0317 – 485578 | pytrik.reidsma@wur.nl |
| Michiel van Dijk (LEI) | 070 – 3358233 | michiel.vandijk@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# *Ons boer met die natuur*: trade-offs between conservation and farming amongst small-scale land-users in the Cape Floristic Region of South Africa

**Description**

Small-scale farming is a common phenomenon in the rural towns of South Africa's Western Cape Province. It is a province well known for its Fynbos vegetation type, a unique biome rich in plant diversity and with a high degree of species endemism. The species richness associated with Fynbos has earned the Cape Floristic Region (CFR) global status as a biodiversity hotspot. The region is also historically well known for its agricultural products such as wheat, wine and fruit. Unique agricultural products derived from the Fynbos biome include rooibos (Asplathus linearis) and honeybush (Cyclopia sp.). Clusters of farming communities in the CFR harvest these species in the wild and sustain their families in Fynbos landscapes. The functions, processes and services derived from natural resources are fundamental to agriculture.

This research is part of a PhD project that aims exploring how both farming and conservation of the vegetation can be combined. Questions that can be part of the MSc thesis are

- What farming systems exist in the Fynbos landscape amongst small-scale land-users? Do typologies emerge?
- How do current practices differ from historical land-use practices and how has this influenced farmer livelihoods and the Fynbos vegetation?
- What are the objectives of small-scale land-users at the farm level?
- How do the farmers influence the natural resource base and what options do they have for sustainable management?

These are examples, but also other topics within the PhD framework can be addressed.

Field work in the Fynbos region is part of the Msc thesis. The base will be Stellenbosch University.

**Collaboration**

Stellenbosch University, Zuid Afrika, Agricultural department

**Location**

Stellenbosch and Wageningen

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Rhoda Malgas | | rmalgas@sun.ac.za or rhoda.malgas@wur.nl |
| Gerrie van de Ven | 0317 – 48 21 40 | Gerrie.vandeVen@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Estimating and explaining yield gaps at field level using frontier analysis - A case study on a Dutch farm

**Description**

Van Den Borne Aardappelen is a 450 ha potato farm located in Reusel, North Brabant (The Netherlands). Precision farming techniques and decision support systems are widely used in this farm, resulting in nearly 'optimal' management, high resource use efficiency and high yields. In addition, an extensive dataset referring to the soil properties and management strategy (quantity, timing and mode of application of inputs) applied in each specific field is being recorded in detail. Quantification of yield gaps is of particular interest as they provide an indication of the possibility for increasing agricultural production without additional increases of external inputs. Yield gaps can be defined as the difference between a benchmark yield (e.g. potential or water-limited yield) and an actual yield obtained by farmers. Explanation of yield gaps is of particular importance as it reveals bottlenecks of the production process and hence provides key-recommendations for future improvement.

Crop growth simulation models are traditionally used to estimate potential and water-limited yields based on information of the biophysical environment (i.e. weather and soil properties). Methods of frontier analysis (e.g. data envelopment and stochastic frontier analysis) may as well be used for a similar purpose if inputs included in the production frontier are defined appropriately. An important advantage of the latter method is that it can be also used to explain yield gaps based on farm management.

The objective of this MSc study is to estimate and explain yield gaps using detailed biophysical and management data of the Van Den Borne Aardappelen potato fields. The study will provide insights in within farm variability. The project provides a great opportunity for linking agronomic theory to practical farm experience and for deepening the knowledge on production ecological concepts and methods of productivity and efficiency analysis.

**Collaboration**

Field trips to Van Den Borne Aardappelen may be organized for data collection and discussions with the farmer (more information about Van Den Borne Aardappelen can be found in http://www.vandenborneaardappelen.com/301/welkom)

**Location**
Wageningen

**Period**
Any time

**Supervisors**

| | | |
|---|---|---|
| Pytrik Reidsma | 0317 – 48 55 78 | pytrik.reidsma@wur.nl |
| João Silva | | joao.silva@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Intersectoral cooperation in organic agriculture

**Description**
Organic agriculture aims at working according to natural cycles and with a balance between plant and animal production. This type of agriculture closes material cycles as much as possible. Organic agriculture in the Netherlands is highly specialized, with as main sectors dairy farming, pig farming, poultry farming, arable farming and outdoor horticulture. Connections between these sectors are very week in terms of size or exchange of (by)products. This has led to unbalanced nutrient cycles at farm, regional and national level (Hofstad & Schröder, 2002; Prins, 2006).

The aim of this study is to analyse the effects of a further closing of nutrient cycles in Dutch organic agriculture, based on the agronomic configuration of 'complete' organic production systems. The main focus is on the agricultural effects in terms of areas of the various sectors, land use within each sector, exchange of (by)products between sectors, productivity per ha and per animal, etc., under different scenarios related to the use of less favoured inputs from conventional agriculture or abroad. Economic aspects are only touched upon.

Modelling offers the opportunity to quantify organic agricultural systems in a transparent and consistent way. In this study we have developed a linear programming model to optimize the configuration of organic agricultural systems, given a set of constraints and selecting from a large number of 'organic activities'. In this case the gross margin of the Dutch organic sector will be maximized.

A large amount of basic material is available.

**Collaboration**
-

**Location**
PPS-Wageningen

**Period**
Any time

**Supervisors**

| | | |
|---|---|---|
| Gerrie van de Ven | 0317 – 48 21 40 | Gerrie.vandeVen@wur.nl |
| Bert Rijk | 0317 – 48 20 56 | hubertus.rijk@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Linking scientific knowledge to farmers' experience and behaviour on soil management in The Netherlands

**Description**

From scientific literature and long term experiments, several measures are known which farmers can take to enhance their long term soil fertility. Examples include the use of green manures in between crops, incorporating crop residues such as straw into their fields or using organic fertilizers such as compost. Yet many farmers in The Netherlands do not adopt these practices.

Within the European research project CATCH-C an online survey was held among Dutch farmers in 2014. The objective of this survey was to find the barriers for adoption of practices which can enhance soil fertility. This survey was based on the theory of planned behavior and was based on semi-structured interviews and therefore developed from the perspective of the farmer.

Currently the results of the survey are being analyzed. Depending on the outcomes, specific attitudes of farmers can be linked to scientific knowledge to create a deeper understanding of the discrepancy between scientific recommendations and everyday practice. We welcome an MSc student to take part in this research. Depending on his or her interest a specific research question and methodology for the thesis can be developed together. Please use the contact details below to make an appointment for further discussion.

**Collaboration**

Depending on specific thesis topic collaboration can be set up with another chair group or department.

**Location**

Wageningen

**Period**

From February 2015 onwards.

**Supervisors**

Renske Hijbeek                                   renske.hijbeek@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# *NUANCES* - Nutrient Use in ANimal and Cropping systems – Efficiency and Scales

## Description
A modelling framework that combines spatial and temporal dimensions of African smallholder farming systems is under development. A primary aim is to synthesize knowledge and analyse tradeoffs of implementing various soil fertility technologies for smallholder farmers in mixed crop/livestock systems in East and Southern Africa. Emphasis is on efficiency of targeting and use of nutrients and legume-based soil improving technologies, with outputs evaluated in terms of costs, benefits and compromises in productivity, economics and environmental services. Our approach is to aim for simplicity to allow wide access and use of the NUANCES framework, whilst encouraging deeper systems analysis around questions of soil fertility management.

Strong gradients or zones of soil fertility exist in many smallholder farming systems in Africa. Some variability in soil fertility is inherent, arising from differences in underlying geology and the catenary position. Zones of soil fertility also arise due to a number of mechanisms within the farming systems. Firstly due to concentration of agricultural produce and organic wastes around homesteads with most woodash and composts being added to home-gardens. Within livestock-based systems the animals serve to concentrate nutrients within the system where they are stalled overnight, and the manure collected from 'kraals' or 'bomas' is often directed to specific crops or fields within the farm. A further mechanism for the creation of 'islands' of fertility is associated with the maintenance of trees such as *Faidherbia albida* within cropping fields.

If N use efficiency (here used to refer to the efficiency of N capture rather than the efficiency of N use within the plant) is poor, then much more of the N available in the crop/soil system will be susceptible to loss. In situations where crop growth is strongly limited by lack of P, and where there is a strong crop response to P the amount of mineral N in the soil that is susceptible to loss decreases strongly with P addition. If response to P is weak due to other problems for plant growth, such as where soil acidity or poor soil physical properties restrict crop response, then as well as realizing only poor crop growth and yield, the potential losses of N from the soil/crop system are increased. Thus efficient targeting of nutrients within the system is dependent on the position within soil fertility gradients.

Analysis of these farming systems is focused on households as the primary units, with analysis of production benefits in terms of nutrients, labour, cash and environmental costs. The aim is to both describe existing systems and understand current practices and to use the framework to design alternative new systems.

## Collaboration
The project involves collaboration with a large number of Universities and national and international research institutes in Africa

## Prerequisites
Several courses are relevant such as Crop Ecology Soil fertility, QUALUS, etc..

## Location
Wageningen and possibilities in Kenya, Tanzania, Uganda and Zimbabwe

## Period
Any time

## Supervisor
Ken Giller                      0317 – 48 58 18          ken.giller@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Land use change in smallholder farming areas, Zimbabwe

**Description**

More than ten years ago, Zimbabwe embarked on a controversial 'fast track' land reform programme, amidst a deepening political and economic crisis. Both the economic crisis and land reform have had major impacts on agricultural production in the country. Agricultural exports plummeted and Zimbabwe's position as 'bread-basket' of the region is now characterized by recurrent food shortages and humanitarian aid. As Zimbabwe's political crisis and land reform captured international public attention, academic studies have tracked the impact of ongoing land reforms (Scoones et al., 2010; Cliffe et al., 2011). Dramatic changes have also taken place in existing smallholder farming areas, but these have received little attention. This is surprising as Zimbabwe's smallholder farmers in Communal Areas used to produce most of the country's food, not the large–scale farming sector targeted by land reform (Andersson, 2007). While some smallholder farming areas remain productive, many areas have witnessed substantial out-migration, shrinking of the cultivated land area, and increased food insecurity. At the same time, agricultural production is less dominated by maize. Traditional food crops such as millet, sorghum and groundnut have re-emerged, a development often said to be related to climate change. The two MSc research projects will investigate the changes in farming over the past decade using a combination of methods including interviews with farmers and other informants, field surveys and remote sensing.

*MSc Project 1*: *Quantifying land use change in selected Communal Areas in Zimbabwe.*
This project will map, quantify and compare land use change in two or three different Communal Areas in Zimbabwe, using GIS and remote sensing techniques. To understand the drivers of these quantitative land use changes and regional differences, the project builds on fieldwork in the respective areas, interviewing farmers, extension workers and local authorities. Project will combine detailed field ground-truthing with remote sensing of farming, including farm configurations and crop distributions over the past 15 years or so.

*MSc Project 2: Understanding land use change at the farm-level.*
This project will study land use change at the farm-scale, relating such changes to input and labour availability, and (shifting) production strategies of rural households in the face of increased poverty, food insecurity and climate change. The project specifically aims to understand diverse farmers' strategies, approaches and aspirations and builds on extensive fieldwork among rural households in a Communal Area in Zimbabwe.

**Prerequisites**

We seek a student for Project 1 with a background in spatial analysis and remote sensing, for Project 2 a student with a background in development studies, or farming systems analysis.

**Location**

Zimbabwe and Wageningen.

**Period**

Any time of year is possible – field work best between November and May.

*References*

Andersson, J.A., 2007. How much did property rights matter? Understanding Food insecurity in Zimbabwe: A critique of Richardson, *African Affairs* **106**(425), pp.681–690.

Cliffe, L. et al., 2011. An overview of Fast Track Land Reform in Zimbabwe: editorial introduction. *Journal of Peasant Studies* **38**(5), 907–938. *(special issue on land reform in Zimbabwe.)*

Scoones, I. with Marongwe, N., Mavedzenge, B., Mahenehene, J., Murimbarimba, F. and Sukume, M (2010) *Zimbabwe's Land Reform: Myths & Realities*, London: James Currey.

- http://www.zimbabweland.net/Videos.html (IDS videos).

- http://www.youtube.com/watch?v=7kTXmJcfPqo (Professor Ian Scoones Dispels The Myths).

**Supervisors**

| | | |
|---|---|---|
| Ken Giller | 0317 – 48 58 18 | ken.giller@wur.nl |
| Jens Andersson | | jens.andersson@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Tradeoffs in resource and labour allocation for implementing soil fertility management options in smallholder farms of Sub-Saharan Africa

## Description

Resource-poor farmers in Sub-Saharan Africa have different strategies to manage crop-livestock systems based on both local and research-driven knowledge. For soil fertility management, a vast set of alternative technologies have been tested in the past, showing promising results for improving/maintaining soil quality and sustaining food production. However, the implementation of such technologies has been considerably limited. Some of these technologies are resource- and/or labour- demanding, and farmers have to make decisions on how to best allocate their scarce resources and labour force between competing activities within their farm (tradeoffs).

This research proposal aims at analysing the factors driving farmers' decision-making and strategies for soil fertility management (SFM) and the constraints for the implementation of innovative SFM technologies. Another major challenge is to integrate such knowledge into functional relationships for decision support tools (models).

Clearly, the problem at stake is of a multidisciplinary nature and may lead to several specific research questions – some of them may also arise once the local reality has been met. A general set of objectives to explore include:

1. To identify farmers' priorities and decision rules on resource and labour allocation to different farm activities (rule-based decision making);
2. To quantify labour demands in time (labour calendars) for different farm activities and SFM technologies/practices;
3. Attempt to quantify the effect of the amount of labour allocated to a certain production activity on its performance (e.g. labour used for weeding vs. crop yield reduction; labour used to cut-and-carry forage vs. milk production and/or manure quality);
4. To identify/analyse main constrains and tradeoffs faced by farmers when making decisions on management (operational, tactic, strategic) and on SFM technology adoption.

Methodologies are diverse and the contribution of the student in defining the most appropriate approach is highly encouraged. Participatory methods, scenario analysis using models, field measurements, econometric analysis and working with farmer field schools (communication) are some of the approaches we propose.

## Collaboration

Field work in collaboration with the International Institute of Tropical Africa (IITA), Nairobi, Kenya.

## Prerequisites

A strong interest in multidisciplinary studies. A successful completion of the specific course load and preferably knowledge on systems analysis and modelling.

## Location/time

East Africa (Kenya, Uganda, Tanzania) / Wageningen (PPS); any time, but preferably February-May or September-December (rainy seasons).

## Supervisors

Ken Giller                     0317 – 48 58 18          ken.giller@wur.nl
Pablo Tittonell                0317 – 48 14 13          pablo.tittonell@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Perennial feed options for improved profitability and environmental resilience of mixed crop-livestock farming systems in southern Australia

**Description**

The *EverCrop* project is investigating the roles that perennials can play to address current and future production and sustainability challenges in the mixed farming system zones of southern Australia. By recognising and responding to whole-farm and management aspects at the farm-scale, *EverCrop* aims to increase profitability, resilience and environmental outcomes. To achieve this, EverCrop has established a unique R, D & E approach that has integrated field experimentation, on-farm trialling, farmer participatory research, farm case studies, soil-plant-climate biophysical modelling and whole-farm bio-economic analysis.

Student projects in Evercrop can take place in the low rainfall node, located in the Mallee region (South Australia and Victoria), where variable climate and soil conditions pose serious challenges to farming enterprises. Field experimentation in the Mallee focuses on testing the performance of forage shrubs and summer-growing perennial grasses in search for options for high risk zones with low cropping potential.

Student projects can focus on one or more of the below objectives:

- Assessment of biomass production and soil cover for different shrub and perennial grass options in experimental trials and farm-level demonstration plots;
- Water flow analysis of perennial feed options based on field measurements and modelling outputs;
- Crop simulation model evaluation for forage shrubs and summer-growing perennials based on primary and secondary data from across southern Australia;
- Scenario analysis using crop models and/or whole farm biophysical models to assess the potential fit for perennials in mixed farming systems.

Depending on their interest, students can decide whether to concentrate on field-based data collection and analysis, or on the modelling aspects.

**Collaboration**

Evercrop project partners, including CSIRO and local farmer groups.

**Prerequisite**

Students with an interest in interdisciplinary work and systems analysis.

**Location/time**

Adelaide (CSIRO) and Wageningen. Students interested in getting involved in the field trials need to plan to be in the region during (part of) the local spring-summer-autumn seasons (October – March). Others are less restricted in terms of time.

**Supervisors**

Katrien Descheemaeker          0317 – 48 61 02          katrien.descheemaeker@wur.nl
Rick Llewellyn (CSIRO)                                        rick.llewellyn@csiro.au

**General information:** Teaching-coordinator (see first page of booklet)

# Will the world have enough to eat?

**Description**

Global food production must nearly double to meet demand as population hopefully stabilizes at +9 billion by 2050. This can in principle be realized through: (1) increasing the extent of agricultural land, (2) closing the yield gap between potential and current yield levels on existing arable land and (3) increasing the potential yield ceiling. In the thesis subject you can investigate research approaches and results of yield gap analyses and their implications for global food availability and land use. Approaches to assess yield gaps may be model-based, experimental, empirical, or a combination of these. Moreover, methods may differ depending on scale of yield gap analysis—from the farm, to regional and national. The thesis can focus on: (a) estimating yield gaps at farm, regional and national levels, (b) strategic efforts to narrow yield gaps in different agro-environmental zones of the world while also reducing the environmental footprint of high-yield systems, (c) genetics and physiological studies that seek to understand and lift yield potentials of major food crops, and (d) implications of yield gap analysis for land use change and food security. Contributions may also refer to policies that facilitate narrowing yield gaps either through generating or applying new knowledge or stimulating efficient use of resources. In all cases, the link to yield gaps should be explicit and well elaborated and preferably trade-offs between production and environmental aims will be addressed.

The aim of this research topic for students would be to:
(i) estimate yield gaps for specific regions in the world using a combination of empirical, experimental or simulated yields and management information;
(ii) study the implications of yield gaps for land use change and global food security;
(iii) study potentials for different crops to lift the yield potential.

**Collaboration**

With various other chair groups of the University, from Plant, Animal or Social Sciences, or Plant Research International. Collaboration with other groups in the world is also possible.

**Prerequisites**

A strong background in agronomy, with interest in quantitative approaches.

**Location**

Wageningen, possibly combined with different locations in the world.

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Martin van Ittersum | 0317 – 48 23 82 | martin.vanittersum@wur.nl |
| Lenny van Bussel | 0317 – 48 30 73 | lenny.vanbussel@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Integration of crop and animal production systems: producing more feed and meat with less land

**Description**

How can an increase in food production of 70% be realized to feed the world population of 9 billion people in 2050? Intensification of agricultural production systems is a strategy to produce more products with less resources. For animal production, there are hardly any general methods to quantify the difference between actual production and the theoretically achievable production.

This MSc research is part of a PhD project that aims to apply the 'production ecological concepts' from crop production systems to animal production systems. The focus is on quantifying meat *production levels* from beef cattle and poultry.

- *Potential production* is determined by the climate and animal genetics
- Feed quantity and/or quality are limiting the *feed limited production*
- The *actual production* takes into account the effects of feed limitation and diseases and stress.

Crop and animal production can be integrated by using the production ecological concepts for both. Crop and animal production systems in Europe, Asia and Africa will be considered.

Research questions that can be part of the MSc thesis:

- What is the origin of feeds used in European, Asian and African beef and poultry production systems and what feed proportions are included in animal diets?
- What yield levels are achieved in feed crops (potential, water and nutrient limited, actual production levels)?
- How much land area is used per kg of meat produced?
- What is the minimum area required per kg of meat?
- What strategies can farmers adopt to minimise land use?
    Crop and animal growth models will be used to address the research questions.

**Collaboration**

Plant Production Systems group and Animal Production Systems group, Wageningen University

**Location**

Wageningen

**Period**

January 2014 onwards

**Supervisors**

Gerrie van de Ven          0317 – 48 21 40          Gerrie.vandeVen@wur.nl
Aart van der Linden         0317 – 48 38 82          Aart.vanderlinden@wur.nl

**Project website:**

http://www.wageningenur.nl/en/show/Benchmarking-animal-production-systems.htm

**General information:** Teaching-coordinator (see first page of booklet)

# Benchmarking agricultural production – towards a yield gap and resource use efficiency atlas

**Description**

Global food production must nearly double to meet demand as population hopefully stabilizes at +9 billion by 2050. This can in principle be realized through: (1) increasing the extent of agricultural land, (2) closing the yield gap between potential and current yield levels on existing arable land and (3) increasing the potential yield ceiling. In the thesis subject you can investigate research approaches and results of yield gap analyses and their implications for global food availability and land use. The thesis work contributes to a Global yield gap and resource use efficiency atlas which provides for different regions in the world the difference between actual and potential production levels and the scope for improving resource use efficiency of land, water and nutrients. Approaches to assess yield gaps may be model-based, experimental, empirical, or a combination of these. The thesis can also focus on technological progress: what is the scope for improving potential and water-limited yields through genetic and breeding progress.

**Collaboration**

With various other chair groups of the University, from Plant, Environmental and Animal Sciences, or Plant Research International. Collaboration with other groups in the world is also possible.

**Prerequisites**

A strong background in agronomy, with interest in quantitative approaches.

**Location**

Wageningen, possibly combined with different locations in the world.

**Period**

Any time

**Supervisors**

| | | |
|---|---|---|
| Martin van Ittersum | 0317 – 48 23 82 | martin.vanittersum@wur.nl |
| Joost Wolf | 0317 – 48 30 78 | joost.wolf@wur.nl |
| Lenny van Bussel | 0317 – 48 30 73 | lenny.vanbussel@wur.nl |
| René Schils | 0317 – 48 47 43 | rene.schils@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

## Integrated assessment of adaptation to climate change of agricultural systems in the North of the Netherlands

**Description**

Agricultural systems in the Netherlands are influenced by changing policies and markets at global, EU and country level. Globally, climate change became an important issue during last decades. In many regions in the world one can already observe effects of the changes and variations in climatic conditions on crop productivity, farmers' income and land use. Also for the future of Dutch agriculture the importance of climate change cannot be ignored; effects of weather extremes seem particularly important.

In order to cope with the effects of climate change farmers in the Netherlands have to develop adaptation strategies. These strategies can include changes in management within the current farming system (size, intensity, specialization) and/or a shift to alternative farming systems. Adaptation strategies can also include alternative functions that the agricultural sector can provide to the society, such as sustainable energy production, nature conservation, care farming, etc. The case study for this project is the Dutch province of Flevoland. Large scale intensive arable farming is the main type of agricultural activity in the region. The main questions to be answered in this study are:

1. Assess the vulnerability of the present farming systems in Flevoland under the changing policy, market and climate conditions.
2. What are possible images of farms of the future in Flevoland and what is the impact of climate change?
3. What adaptation strategies can be implemented by arable farmers in Flevoland to maintain income, yields and environmental performance?
4. What research tools can be applied to assess the adaptation strategies to climate change of arable farmers in Flevoland?

The research methods that can be used in the study include crop growth simulation and bio-economic models, scenario analysis and cost-benefit analysis.


**Location**
Wageningen

**Period**
Any time


**Supervisor**
Pytrik Reidsma                    0317 – 48 55 78                    pytrik.reidsma@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

# Agricultural adaptation to climate change in multifunctional landscapes

**Description**
Agriculture in Europe evolves due to changes in policy, socio-economic and climatic conditions. In the Netherlands, over the past 50 years, the overall number of farms decreased by 75%, while the average farm area increased from 6 to 26 ha. When looking ahead, some rural areas will remain production oriented, others will move to a more multifunctional character. For both types of farming there is a need to identify adaptation strategies that are effective in achieving climate-robust agricultural landscapes, contributing to social, economic and environmental objectives.
A climate-robust, multifunctional rural landscape can only be obtained if farmers contribute to nature targets. A substantial number of farmers is willing to contribute to biodiversity conservation, but they need economic incentives. Trade-offs between food production, farmer's income and environmental services should be assessed to identify effective and feasible cross-sectoral adaptation strategies.
This research will assess the consequences of agricultural adaptation strategies to climate, market and policy changes on different farm types and the implications for nature quality in the rural areas. Bio-economic farm modelling will be used, but it is also possible to perform studies at crop level (using crop models and participatory methods) and at landscape level (using agent-based modelling or genetic algorithms). Studies can focus on the modelling itself, but also on the analysis of information required for modelling (i.e. interviews with stakeholders, statistical analysis of data).

**Collaboration**
Depending on the specific subject, collaboration is possible with other groups in Wageningen and/or with the University of Edinburgh.

**Prerequisites**
Interest in quantitative analysis and modelling. Completion of the PPS course Quantitative Analysis of Land Use Systems (QUALUS) and knowledge on biodiversity research will be an advantage.

**Location**
Wageningen

**Period**
Any time

**Supervisors**

| | | |
|---|---|---|
| Pytrik Reidsma | 0317 – 48 55 78 | pytrik.reidsma@wur.nl |
| Martin van Ittersum | 0317 – 48 23 82 | Martin.VanIttersum@wur.nl |

**General information:** Teaching-coordinator (see first page of booklet)

# Climate Smart Agriculture (CSA)

**Description**

Although the link between food security, agriculture and climate change is clear, the issues are still addressed separately at the national and international level. Commonly the farm level is the main integrator. At this level all issues converge and define the decision making environment for farmers. Food security policies focus on the integration of two major drivers: production and market, but so far fail to address climate change concerns. Climate change shifted from being an environmental issue to a development issue but this is not yet reflected in most national and international policies in which the two pillars *adaptation* and *mitigation* are handled as separate issues. Also the institutional setting is such that the main players are found in the environmental institutions. Most climate change studies have focused on either reductions in emissions or adaptation strategies to the adverse effects of climate change and climate variability. Recently, however, the climate change issue is increasingly being incorporated in the larger challenge of sustainable development. The importance of agriculture for sustainable development of developing countries is obvious. Moreover food security remains a top priority for many countries. Priority will be to address urgent and immediate needs linking to on-going development plans and policies on food security. Policy and farm level recommendations and activities will however have to be aligned to medium and long term planning processes and objectives.

This is not a trivial task. Besides lack of knowledge, capacity and tools to make Climate Smart Agriculture (CSA) work, institutional, social, legal and technical barriers to implement CSA may exist. The implementation of CSA at the farm level is a critical step and has to be addressed.

The primary goal is to identify barriers to adopting and sustaining agricultural practices that increase yield and at the same time promote resilience while aiming for low greenhouse gas intensity of agricultural products. The study will focus on potato production systems in Europe, South America and Africa.

The secondary goals is to:
formulate farm level (and landscape) recommendations to implement CSA

**Collaboration**
To be decided.

**Prerequisites**
Working knowledge of English, basic understanding of farming systems.

**Location**
Wageningen

**Period**
Start any time before 2015

**Supervisor**

Jan Verhagen                    0317 – 48 05 63                    jan.verhagen@wur.nl

**General information:** Teaching-coordinator (see first page of booklet)

## Can farmers benefit from techniques to reduce agricultural greenhouse gas emissions

**Description**
The agriculture sector faces significant challenges in meeting the increase in global food demand, while at the same time reducing its contribution to greenhouse gas emissions.
Agriculture plays a vital role in food security, poverty reduction and sustainable development. But agriculture currently also produces 14 percent of the world's annual greenhouse gas emissions, about the same as the transport or stationary energy sectors. So on the one hand agriculture is particularly vulnerable to the impacts of climate change, on the other hand it has itself a great influence on climate change.
Whilst climate change is a global concern, practices to reduce emissions have to be adopted at farm level. Knowledge is available on how to reduce the emissions of agricultural greenhouse gasses. It is generally believed that reduction of greenhouse gas emissions goes hand in hand with increased efficiency of input and nutrient utilisation. However, it is not always known what the costs and benefits are for an individual farmer when adopting this knowledge.
Your assignment is to:
- Provide an overview of agricultural research results and technologies that have the potential to reduce greenhouse gas emissions, with a particular focus on potato and livestock production.
- Identify how and under what conditions this knowledge and techniques can be applied by farmers in various parts of the world.
- If this knowledge and techniques were applied; what are the benefits for the individual farmer, and what are the effects in reducing greenhouse gas emissions.

**Collaboration**
The Global Research Alliance (GRA) on Agricultural Greenhouse Gases was launched in December 2009 and now has 40 member countries from all regions of the world. The Alliance is focused on research, development of technologies and practices that will help deliver ways to grow more food (and more climate-resilient food systems) without growing greenhouse gas emissions.
The GRA aims to deepen and broaden mitigation research efforts. Groups have been set up to address these areas of work. These Groups bring countries and other partners together in research collaborations, they share knowledge and best practices, build capacity and capability amongst scientists and other practitioners, and move towards breakthrough solutions in addressing agricultural greenhouse gas emissions. The GRA focusses till now on research and research collaboration.
To create impact in the reduction of greenhouse gas emissions, engagement of farmers is necessary. Research results have to be adopted by farmers, but therefore technologies have to be adapted to farmers needs and possibilities and have to be profitable for farmers.
An important challenge in the adoption of techniques that reduce emissions is to find the solution whereby farmers also experience a direct advantage.

**Prerequisites**
Working knowledge of English, basic understanding of GHG emissions and farming systems.

**Location**
Wageningen

**Period**
Start any time before 2015

**Supervisors**
| | | |
|---|---|---|
| Jan Verhagen | 0317 – 48 05 63 | jan.verhagen@wur.nl |
| Henk van der Mheen | 0317 – 48 70 34 | henk.vandermheen@wur.nl |
| Theun Vellinga | | |

**General information:** Teaching-coordinator (see first page of booklet)

## Miscellaneous possibilities

Apart from the projects mentioned in the previous pages, there are occasionally possibilities to do research in other topics as well.

**General information:** Teaching-coordinator (see first page of booklet)

## Plant Production Systems Group
### *Leerstoelgroep Plantaardige Productiesystemen*

| Professors | E-mail | Telephone |
|---|---|---|
| Ken E. Giller (Head) | ken.giller@wur.nl | (+31)-(0)317-(4)85818 |
| Martin K. van Ittersum | martin.vanittersum@wur.nl | (+31)-(0)317-(4)82382 |
| Meine van Noordwijk | meine.vannoordwijk@wur.nl | (+31)-(0)317-(4)82141 |

| Secretariat | | |
|---|---|---|
| Ria van Dijk (ma, wo, vr) | ria.vandijk@wur.nl | (+31)-(0)317-(4)82141 |
| Charlotte Schilt (ma, di, do) | charlotte.schilt@wur.nl | (+31)-(0)317-(4)82141 |
| Alex-Jan de Leeuw (two dpw) | alex-jandeleeuw@wur.nl | (+31)-(0)317-(4)85111 |

| Scientific Staff | | |
|---|---|---|
| Peter A. Leffelaar | peter.leffelaar@wur.nl | (+31)-(0)317-(4)83918 |
| Pytrik Reidsma | pytrik.reidsma@wur.nl | (+31)-(0)317-(4)85578 |
| Katrien Descheemaeker | katrien.descheemaeker@wur.nl | (+31)-(0)317-(4)86102 |
| Maja A. Slingerland | maja.slingerland@wur.nl | (+31)-(0)317-(4)83512 |
| Gerrie van de Ven | gerrie.vandeven@wur.nl | (+31)-(0)317-(4)82140 |
| Joost Wolf | joost.wolf@wur.nl | (+31)-(0)317-(4)83078 |
| René Schils | rene.schils@wur.nl | (+31)-(0)317-(4)84743 |
| Tom Schut | tom.schut@wur.nl | (+31)-(0)317-(4)82454 |
| Joost van Heerwaarden | joost.vanheerwaarden@wur.nl | (+31)-(0)317-(4)86940 |
| Paul Burgers | paul.burgers@wur.nl | (+31)-(0)317-(4)86940 |
| Jiska van Vliet | jiska.vanvliet@wur.nl | (+31)-(0)317-(4)82141 |

| Post-Doc Staff | | |
|---|---|---|
| Lenny van Bussel | lenny.vanbussel@wur.nl | (+31)-(0)317-(4)83073 |

| Technical Staff | | |
|---|---|---|
| Marcel Lubbers | marcel.lubbers@wur.nl | (+31)-(0)317-(4)82056 |
| Mink Zijlstra | mink.zijlstra@wur.nl | (+31)-(0)317-(4)84771 |
| Bert Rijk | bert.rijk@wur.nl | (+31)-(0)317-(4)82056 |
| Greta van den Brand | greta.vandenbrand@wur.nl | (+31)-(0)317-(4)84769 |

**PhD Research**

| | |
|---|---|
| Benjamin Kibor | (Ken Giller, Bernard Vanlauwe, Pieter Pijpers) |
| Maryia Mandryk | (Martin van Ittersum, Pytrik Reidsma, Bas Arts) |
| Joao Guilherme Dal Belo Leite | (Martin van Ittersum, Maja Slingerland, Jos Bijman) |
| Leonardo, Wilson J. | (Ken Giller, Almeida Sitoe, Gerrie van de Ven, Henk Udo) |
| Sheida Sattari | (Ken Giller, Martin van Ittersum, Lex Bouwman, Bert Smit PRI) |
| Godfrey Taulya | (Ken Giller, Peter Leffelaar, Piet van Asten) |
| Mezegebu Debas | (Martin van Ittersum, Huib Hengsdijk) |
| Merel van der Wal | (Carolien Kroeze, Joop de Kraker, Paul Kirschner (Open University), Martin van Ittersum) |
| Steven Matema | (Akke van der Zijpp (APS), Ken Giller, Jens Andersson, Imke de Boer) |
| Juliana Tjeuw | (Ken Giller, Maja Slingerland, Raymond Jongschaap) |
| Stanley Karanja Ng'ang'a | (Ken Giller, Mariana Rufino, Erwin Bulte) |
| Edouard Rurangwa | (Ken Giller, Linus Franke, Mark van Wijk) |
| Renske Hijbeek | (Martin van Ittersum) |
| Ghislaine Bongers | (Ken Giller, Piet van Asten) |
| Kodjovi Senam Ezui | (Ken Giller, Linus Franke) |

| | |
|---|---|
| Michael Kermah | (Ken Giller) |
| Esther Masvaya | (Ken Giller) |
| Gatien Falconnier | (Ken Giller, P.Q. Craufurd, T. van Mourik) |
| Fang Gou | (Wopke van de Werf, Martin van Ittersum) |
| Siriluk Somnuek | (Ken Giller, Maja Slingerland) |
| Sakti Hutabarat | (Erwin Bulte, Kees Burger, Ken Giller, Maja Slingerland) |
| Niharika Rahman | (Ken Giller, Jakob Magid, Thilde Bech Bruun, Andres de Neergaard) |
| Martha Ross | (Erwin Bulte, Lonneke Nillesen, Ken Giller) |
| Aart van der Linden | (Simon Oosting, Gerrie van de Ven, Imke de Boer, Martin van Ittersum) |
| Mary Ollenburger | (Ken Giller, Katrien Descheemaeker) |
| Eskender Beza | (Lammert Kooistra, Pytrik Reidsma, Martin Herold, Arnold v.d. Bregt) |
| Joao Vasco Silva | (Ken Giller, Martin van Ittersum, Pytrik Reidsma, Erwin Bulte) |
| Esther Ronner | (Ken Giller, Linus Franke, Katrien Descheemaeker) |
| Beyene Teklu Mellisse | (Ken Giller, Gerrie van de Ven, Katrien Descheemaeker) |
| Lotte Woittiez | (Ken Giller, Maja Slingerland, Thomas Fairhurst) |
| Daniel van Vugt | (Ken Giller, Linus Franke, Joost Wolf) |
| Heleen van Kernebeek | (Martin van Ittersum, Imke de Boer, Simon Oosting) |
| Tesfaye Shiferaw Sida | (Ken Giller, Frédéric Baudron) |
| Nimatul Khasanah | (Meine van Noordwijk, Ken Giller) |
| Rika Ratna Sari | (Meine van Noordwijk, Ken Giller) |
| Danny Dwi Saputra | (Meine van Noordwijk, Ken Giller) |
| Delelegne Abera | (Jos Bijman, Onno Omta, Maja Slingerland) |
| Lotte Klapwijk | (Ken Giller) |
| Jannike Wichern | (Ken Giller, Katrien Descheemaeker, Mark van Wijk) |
| Ilse de Jager | (Inge Brouwer, Ken Giller) |

| | |
|---|---|
| Contact for visitors: | Ria van Dijk / Charlotte Schilt (secretariat) |
| Visiting address: | Droevendaalsesteeg 1, 6708 PB Wageningen |
| Postal address: | P.O. Box 430, 6700 AK Wageningen, The Netherlands |
| Internal mail: | Bodenummer 71 |
| Telephone: | (+31) (0)317-48 21 41 |
| Telefax: | (+31) (0)317-48 48 92 |
| E-mail: | office.pp@wur.nl |
| Web-site: | http://www.pps.wur.nl/UK/ |

**Web-sites**

| | |
|---|---|
| Department of Plant Sciences | http://www.intranet.wur.nl/nl/home/Pages/home.aspx |
| Wageningen University | http://www.wur.nl/ |

**Notes**