RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security

Workshop report: Farm-household modelling with a focus on food security, climate change adaptation, risk management and mitigation: a way forward

May 2012

Mark T. van Wijk, Mariana C. Rufino, Philip K. Thornton

Farm-household modelling with a focus on food security, climate change adaptation, risk management and mitigation: a way forward

Workshop Report

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Mark T. van Wijk, Mariana C. Rufino, Philip K. Thornton

Correct citation:
van Wijk MT, Rufino MC, Thornton PK. 2012. Farm-household modeling with a focus on food security, climate change adaptation, risk management and mitigation: a way forward. CCAFS Workshop Report. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

CCAFS Workshop Reports aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

Published by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

CCAFS is a strategic partnership of the CGIAR and the Earth System Science Partnership (ESSP). CGIAR is a global research partnership for a food secure future. The program is supported by the Canadian International Development Agency (CIDA), the Danish International Development Agency (DANIDA), the European Union (EU), and the CGIAR Fund, with technical support from the International Fund for Agricultural Development (IFAD).

Contact:
CCAFS Coordinating Unit - Faculty of Science, Department of Plant and Environmental Sciences, University of Copenhagen, Rolighedsvej 21, DK-1958 Frederiksberg C, Denmark. Tel: +45 35331046; Email: ccafs@cgiar.org

Abstract

The workshop entitled: 'Farm-household modelling with a focus on food security, climate change adaptation, risk management and mitigation: a way forward' focused on identifying the current strengths and weaknesses of farm and household-level models, and laying out practical pathways to improve these models. This activity followed a recent review on farm household modelling commissioned by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The workshop took place in Amsterdam, The Netherlands on 23–25 April 2012. The most important conclusions of the workshop were:

1. It is possible to analyse household-level questions related to climate change in a reasonable short (6 months to 1 year) time span with existing tools and the expertise present in the group of participants.
2. Availability of component tools can be an issue; the tools are there but free usability of code and parameters is not always possible.
3. Activities to develop repositories of models and data are urgently needed to increase further development of household models and make better use of existing knowledge.

A set of activities will be developed to move the work forward in three CCAFS target regions (West Africa, East Africa and South Asia). The expectation is that the workshop will serve as a springboard for a multi-year initiative that will eventually involve a wide range of participants both within and outside the CGIAR. The challenges associated with climate change, agriculture and food security are considerable, and household modelling has a key role to play in designing and evaluating adaptation, risk management and mitigation options that can help lead to the positive outcomes that CCAFS and research-for-development partners are seeking.

Keywords

Climate change; Household modelling; Smallholder farming; Workshop

About the authors

Mark T. van Wijk, Sustainable Livestock Futures Theme, International Livestock Research Institute (ILRI), Nairobi, Kenya and Wageningen University, the Netherlands.

Mariana C. Rufino, Sustainable Livestock Futures Theme, International Livestock Research Institute (ILRI), Nairobi, Kenya.

Philip K. Thornton, CCAFS Theme 4, International Livestock Research Institute (ILRI), Nairobi, Kenya.

Contents

Introduction

The Sustainable Livestock Futures Theme of International Livestock Research Institute (ILRI) organized a workshop entitled: “Farm-household modelling with a focus on food security, climate change adaptation, risk management and mitigation: a way forward”. The workshop focused on identifying the current strengths and weaknesses of farm and household-level models, and laying out practical pathways to improve these models. This activity followed a recent review on farm household modelling commissioned by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). The workshop took place in Amsterdam, The Netherlands on 23–25 April 2012.

Workshop program

Day 1: 23 April 2012, 0900-1700

General introduction of goals of the workshop and overview of state-of-the-art in farm household modelling: where are the knowledge gaps?

Mariana Rufino: Goals of the workshop

Philip Thornton: Introduction: The vision of CCAFS

Mario Herrero: What type of systems is CCAFS focusing on and which sort of questions do we want to answer?

Presentation of modelling approaches by workshop attendants (15 minutes each; list of model characteristics / attributes)

Breakout session: what are current model weaknesses? How can they be addressed? Group work

Plenary discussion of breakout session findings

Day 2: 24 April 2012, 0900-1700

During this day and first half of Day 3 contrasting case studies were worked out. The organizers provided a system description, type of data available (primary and secondary data), and key research questions for the sites related to climate change, risk, adaptation and food security.

The participants discussed the development of a combined set of models, which could be used to address these questions:

- For different research questions, what different models can be used?
- Which type of model is strong in what?
- How can existing models be combined so that the weaknesses of each model approach are covered?
- How should these models be improved to better address the questions?

After short sessions, the groups ended up with a description of a coherent suite of models to address climate change, risk, adaptation and food security related questions in an integrated way.

Day 3: 25 April 2012, 0900 –1700

Day 2 continued.

We defined research pathways to develop and apply the coherent set of models across CCAFS sites and address the weakness present in current models. This could potentially lead to funding of key steps by CCAFS and other partners.

Processes

Introduction of models used by participants.

Day 1 of the workshop, 1100–1530

Breakout session: 3 groups of five people each discussed the strengths and weaknesses of state-of-the-art household models in relation to 5 key questions / interests of CCAFS:

- Representation of uncertainty (in input and of model system) and risk over time
- Flexible farm-level decision-making (using optimization or heuristic techniques)
- Causes and outcomes of progressive adaptation over time
- Assessment of trade-offs and synergies between food production, food security, farm economics, ecosystem services, environmental impact (for example greenhouse gases [GHG] emissions) resulting in pro-poor mitigation, and including the economics of mitigation
- Improved use of household models for up and down scaling purposes, including feedbacks across spatial and temporal scales

The results of the breakout session were presented by each of the groups. These presentations were then followed by a plenary discussion

Day 1 of the workshop, 1600 –1800

- Introduction of the CCAFS sites (presentation by Mark van Wijk, 0900 – 0930).

Breakout session: 3 groups of five people defined key indicators to assess climate change effects on key indicators of the farm household system.

The results of the breakout session were presented by each of the groups followed by a plenary discussion

Day 2 of the workshop, 0930 –1230

- Breakout session: 3 groups of five people had to define models and methods to quantify each of the key indicators selected in the previous session.

The results of the breakout session were presented by each of the groups followed by a plenary discussion

Day 2 of the workshop, 1400 –1800

- Introduction and description by Mariana Rufino of a concrete system to be analysed. Task for breakout groups: Develop a model framework to analyse interventions to reduce the risk of food shortages under climate change, increased competition for resources and uncertain market conditions.

Breakout session: 3 groups of five people discussed for 1.5 hours how to answer the question.

The results of the breakout session were presented by each of the groups, and was followed by a plenary discussion

Day 3 of the workshop, 0930 –1200

- Philip Thornton presented his conclusions of the workshop and sketched the developments that might happen after the workshop, and how the momentum and collaboration built up during the workshop could be continued.

Outcomes of the discussions

Introduction of modelling approaches and case studies by participants

Thomas Berger, Lieven Claessens, Roberto Valdivia, David Parsons, Charles Nicholson, Guillaume Martin, Philip Thornton and Meine van Noordwijk each introduced the type of model they use or have used to analyse questions at the farm-household level. The presentations showed that the participants use a wide range of modelling techniques and

approaches, and that the models differ in the type of questions on which the model developers have focused. Each presentation was followed by a short discussion on the concepts used in the models, and how they could be used for answering questions related to climate change.

Some key remarks from the discussions:

- Static analyses are insufficient to account for risk (i.e. defined as the probability of a hazard and that can be environmental of socio-economic of nature). Dynamic analyses are essential for capturing the time structure of climate and other sources of risk and cumulative impact of risk on household livelihoods.
- To address poverty and food security, the model must be able to keep track of assets dynamics and capacity for food storage or at least should capture the change of these assets due to climate change and adaptation.
- The description of decision-making in the modelling approach must be relevant and sensitive to the sort of interventions to be tested.
- The models should account for adoption: what does it take to be an early adopter, and what is the probability of adoption; the estimates of the probability of adoption need to be linked to other socio-economic and environmental outcomes (for example. poverty, farm income, nutrition, soil quality, and so on).
- The model should also account for heterogeneity in farming systems; this can be important in the climate change context, for adaptation and for policy interventions.

Breakout session: Strengths and weaknesses of state-of-the-art household models in relation to 5 key questions of interest to CCAFS

The results and the plenary discussion made clear that current models have weaknesses at different levels. Some participants emphasized that the description of production at the component level (e.g. livestock, crops) is still unreliable in many systems. Other participants argued that the description of decision-making at farm level is particularly uncertain, and that each approach to modelling decisions has significant drawbacks. Each of the 5 questions (see page 3 section 3.2) has been addressed in specific studies, but there are no tools and studies available that have studied all 5 questions in an integrated manner.

Guillaume Martin from INRA emphasized that most modelling projects focus on model development and case studies, which seldom include the testing and implementation of modelling results.

Breakout session: Key indicators to assess climate change impacts on farm households

Following the presentation of the results of the individual breakout groups, the plenary discussion focused on defining a coherent set of indicators, or model outputs of importance, for assessment of potential climate change effects on farm or household level. After ample discussion the following set was defined:

Dynamics of asset accumulation

- Livestock (species, type, condition)
- Trees
- Grain stocks, food storage
- Cash
- Supply of credit (collateral; social networks as a source of remittances)
- Land quality and quantity
- Durables
- Knowledge
- Social networks
- Innovativeness

Food security: availability, accessibility and utilization of food.

- Food consumption relative to demand, energy and nutrients
- Dietary diversity
- Intra household variability

Labour availability versus demand disaggregated over age and gender.

Environmental services

- Life Cycle Analysis of GHG
- Water balance
- Soil nutrients and carbon
- Biodiversity

Poverty

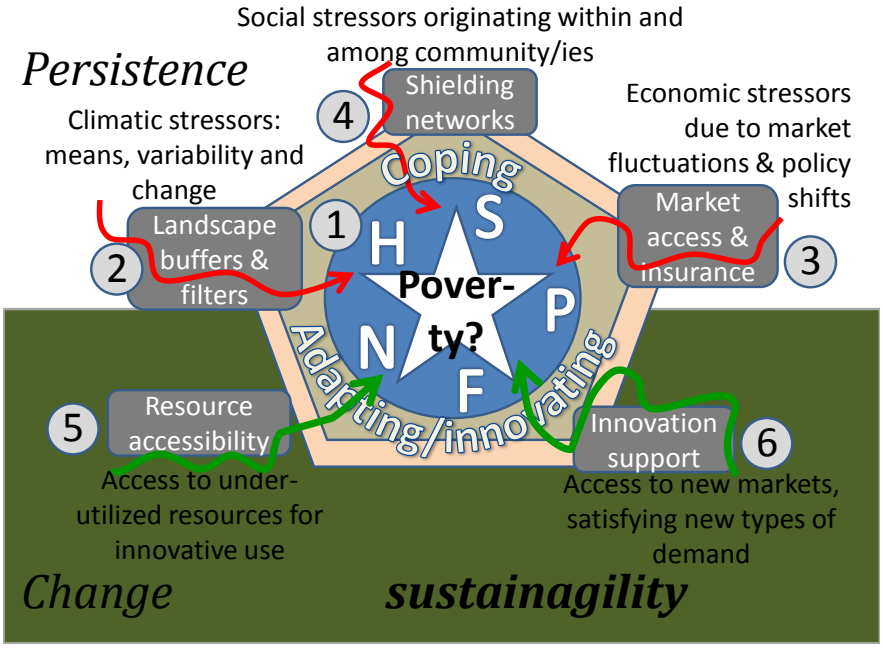
- Development and variation of assets over time
- Income, income diversity, activity diversity
- Non-income based (rights, health, nutrition)

- Dependency of off-farm resources

Breakout session: Models and methods to quantify each of the key indicators to assess climate change effects on the functioning of farm households.

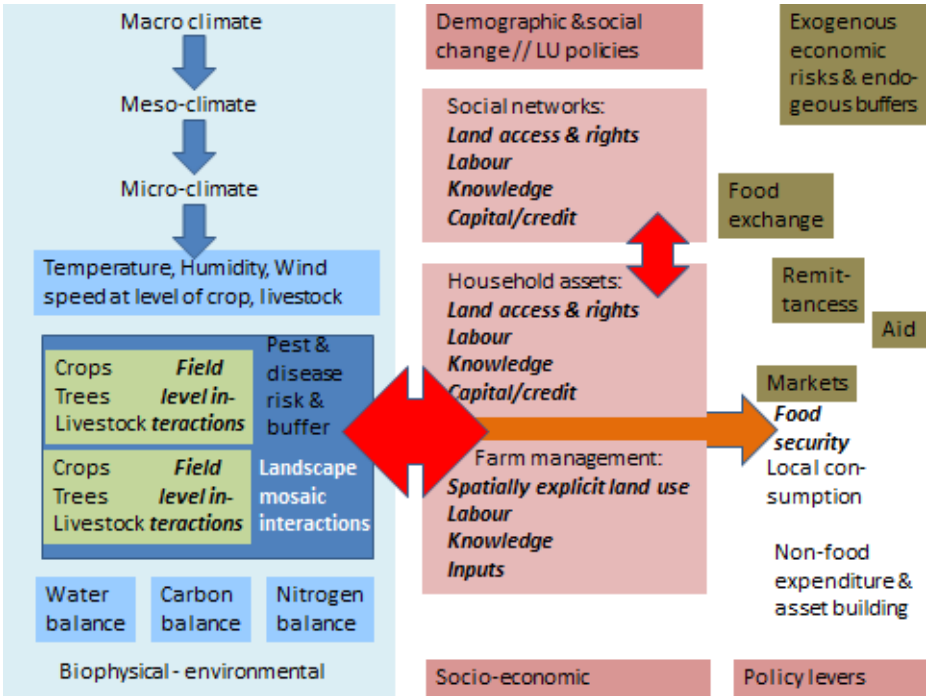
Two key figures were defined in which the indicators and the type of analyses needed were summarized.

Figure 1: Definition of different classes of indicators, and the position of the household in relation to differing buffering mechanisms



Courtesy of Meine van Noordwijk

Figure 2: Key elements in a farm / household model dealing with questions related to climate change



Courtesy of Meine van Noordwijk

A general discussion was held on the elements that should be included in a modelling framework to analyse the key questions posed by CCAFS. First the discussion focused on the general model characteristics. The results are summarized below.

General model characteristics

The participants agreed that a suite of models is needed if we want to model more than climate change impacts, e.g., climate variability, mitigation incentives, risk management and adaptation interventions. Models are needed that range from scientifically sophisticated ones to board games that are directly applicable with farmers.

Production components models that are needed are:

- Crop simulation models
- Livestock simulation models
- Tree-crop simulation models
- Grazing land simulation models

Important considerations for modelling resource allocation and decision-making are:

- Decision making models deliver key input for the crop and livestock simulation models
- Representation of a range of behavioural options is necessary
- Possible objectives in decision making models can be
    - Maximization (profit, expected utility [quality of life], or social status [e.g. livestock])
    - Minimization of time spent in activities
    - Minimization of transactions costs
    - Minimization of the probability of catastrophic loss
- What kind of information is available to the farmer and how is it used
- What are the expectations of the farmer around prices and weather

Important considerations for modelling food security and food self-sufficiency:

- Gathering (from common resources) of food and feed
- Exchanges, gifts, purchases, sales
    - Document importance and patterns over time (coping mechanisms)
    - Social network analysis for exchanges and gifts?
- Storage and carryover of food stocks
- Translation of food amounts into nutrients
    - Calories, protein, micronutrients (which?)
    - Need dietary requirements of household members
    - Index of dietary diversity could be interesting for comparisons across sites
- Intra-household allocation (consumption by individual household members)
    - Difficult, but could be assessed through various behavioural models

For the simulation of the resources available at household level (assets), the following components are important:

- Land access and rights (private and common)
- Labour, knowledge

- Capital (cash available, credit), equipment, etcetera
- Purchased inputs and transactions costs
- Irrigation or common infrastructure

Key characteristics for the drivers to be analysed:

- Stochastic elements: stochastic drivers are typically time series, and therefore we have to give attention to the time structure of these series (e.g., trends, seasonality, autocorrelation)
    - Mean, variance, higher moments, covariance
    - Exogenous: climate, disease and pest risk (partially driven by climate)
    - What about prices? (Exogenous or endogenous? Prices are exogenous to the household, but can be partly endogenous to a local community through local market supply and demand).
- Important to note here that climate, prices and disease risks are all correlated, and information about these correlations is often lacking.
- Policy interventions, for example:
- Knowledge/technology development, regulations, incentives, resource transfers
- Exogenous socio-economic drivers, for example:
- Population, income, urbanisation, input (petrol) costs, demand growth (prices grains, livestock)

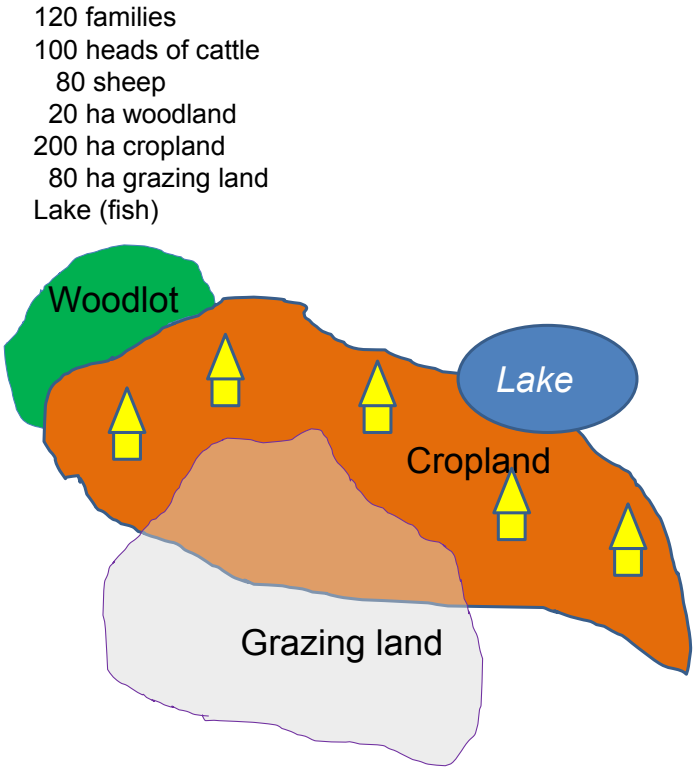
Typical farm or household level model studies will deal with time horizons of 10 to 20 years. A typical starting point for the temporal precision of decision-making could be per month, depending on the information available. Several processes will need spatially explicit representation, for example flows of water and nutrients, and erosion. It is clear that several of the model characteristics suggested in this section are context-specific (in some systems they are needed to represent system functioning well, in other they can be left out without any problem). This suggests a need for flexible modelling tools and approaches. The definition of what is included in a household is also very important, and should be specified. For example, if household members leave the farm to live far away in a big city, this could still mean they have a significant effect on household functioning (e.g. through remittances). Higher-level resource accessibility should therefore be taken into account, because it can be the most important factor to be able to deal with climate or market shocks.

Hypothetical case study

Mariana Rufino (ILRI) introduced a system that should be analysed with a model framework. The system presented is summarized in Figure 3. The participants were asked to think of the sort of tools needed to analyse this system, keeping on mind that the intervention to be designed would use the household level as entry point. The modellers were told that the project would have a time span of 1 year and that the interventions identified were going to be implemented by the donor who requested the study, and therefore needed to be realistic.

The exercise had to focus on a community who cropped private land, and shared a piece of woodland, a fragmented grazing land, and a small lake with fish (see Figure 3). Neighbouring communities sometimes consumed part of the common resources too. The key indicator for evaluating the usefulness of the technologies was food availability. The groups were given 1,5 hours to think of the elements to carry out the research and modelling project successfully using the time span available and limited financial resources.

Figure 3: Summarized, schematic presentation of example system to by studied in the breakout sessions of day 3 of the workshop



Courtesy of Meine van Noordwijk

Breakout session: Definition of key indicators to assess climate change effects on the functioning of farm household

It was clear from the presentation by all groups that more information of the system was needed to be able to decide on the complexity of the model framework. This information could be obtained by community resource mapping:

- Key informant interviews, rapid rural appraisals
- Characterize households based on survey, stratify households
- Assess power relations and institutional setup (incl. marketing) with 'net-map' tool
- Decide on model complexity needed (component models, spatially explicit, interactions)

Based on this information the model framework can be developed step by step.

Model framework

A strategy to be followed could look like this:

- Start simple, parsimonious, mathematical programming models of individual households, avoid interactions and feedbacks when they are not important. Use sensitivity analysis to quantify which interactions need to be accounted for.
- Household model: start with individual non-interacting household models, then use a nested approach (classes of households), only use an interacting agents and spatially-explicit approach when needed (based on sensitivity analysis).
- Fully connected agent-based models might be needed for some sub-systems for example grazing and woodland that are shared by many users.
- Depending on type of intervention, detailed daily time step models might be needed (e.g. change of sowing date, fertilizer application, and so on)
- Sensitivity analysis for timeframe of decision making (year, season, shorter term decisions)
- Coupled biophysical models/modules (crops, livestock, grazing land, woodland) combined with household decision making model could be the final step.

An essential step in the development of the model framework is the identification of the adaptation options to be tested. It was clear there was need to use a participatory approach in which the model is improved after several iterations with the local people. An approach to be followed could include:

- Key informants can be used to identify existing and conceivable adaptation strategies (technologies and policies). A farm typology could be used to reduce the number of farms that need to be simulated, but this typology must be relevant for the sort of interventions to be tested.
- Identified strategies simulated with model system (uncertainty & sensitivity testing)
- Important to feed back (intermediary) model results to key stakeholders to check feasibility (participatory simulation modelling approach).
- Proceed with a stepwise improvement of model system and types of interventions simulated.

The analysis of the scenarios and the evaluation of these in terms of food availability can follow this approach:

- Scenario definition to isolate climate related effects vs. market effects
  - Baseline scenario: current climate and price variability and coping mechanisms
  - Future climate and price change/variability with existing coping mechanisms
  - Future climate and price change/variability with proposed interventions
  - Socio-economic scenarios (RAPs) (population, farm sizes, prices)
- Indicator: differences in food security across population and over time
  - Identify possible winners and losers
  - Assess adaptive capacity in sustainable livelihood framework (assets)
  - Ex-ante testing of effectiveness of interventions (impact, targeting, cost of intervention)

Conclusion

The workshop ended with a short presentation by Philip Thornton on his evaluation of the usefulness of the workshop, and a plenary discussion took place, which reached the following conclusions:

4. The workshop was very constructive.

5. Insight was obtained by participants into the different approaches taken for household level modelling which often need to include higher levels of integration to capture key drivers.
6. It is possible to analyse household-level questions related to climate change in a reasonable short (6 months to 1 year) time span with existing tools and the expertise present in the group of participants.
7. Availability of component tools (e.g. at livestock, crop, grassland or soil level) can be an issue; the tools are there but free usability of code and parameters is not always possible.
8. Activities to develop repositories of models and data are urgently needed to increase further development of household models and make better use of existing knowledge.
9. Concerning next steps, it was agreed that a set of workshop notes would be developed and circulated, for putting on the CCAFS website alongside the household model review. At the same time, a set of activities will be developed to move the work forward in all three of the existing CCAFS target regions (West Africa, East Africa and South Asia). The expectation is that the workshop will serve as a springboard for a multi-year initiative that will eventually involve a wide range of participants both within and outside the CGIAR. The challenges associated with climate change, agriculture and food security are considerable, and household modelling has a key role to play in designing and evaluating adaptation, risk management and mitigation options that can help lead to the positive outcomes that CCAFS and research-for-development partners are seeking.

Appendix

List of participants

Thomas Berger, Chair of Land Use Economics in the Tropics & Subtropics, Universität Hohenheim, Germany

Lieven Claessens, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Nairobi, Kenya

Sika Gbegbelegbe, International Maize and Wheat Improvement Center (CIMMYT), Nairobi, Kenya

James Hansen, CCAFS Theme 2, International Research Institute for Climate and Society, Columbia University, USA

Mario Herrero, Sustainable Livestock Futures Theme, International Livestock Research Institute (ILRI), Nairobi, Kenya.

Amy Ickowitz, Center for International Forestry Research (CIFOR), Bogor, Indonesia

Eike Luedeling, World Agroforestry Center, Nairobi, Kenya

Guillaume Martin, Institut National de la Recherche Agronomique (INRA), Toulouse, France

Charles F. Nicholson, California Polytechnic State University, San Luis Obispo, Agribusiness, USA

Meine van Noordwijk, World Agroforestry Center, Bogor, Indonesia

David Parsons, University of Tasmania, Australia

Mariana C. Rufino, Sustainable Livestock Futures Theme, International Livestock Research Institute (ILRI), Nairobi, Kenya

Philip K. Thornton, CCAFS Theme 4, International Livestock Research Institute (ILRI), Nairobi, Kenya

Nuong Tran, World Fish, Penang, Malaysia

Roberto. Valdivia, Oregon State University, USA

Mark T. van Wijk, Sustainable Livestock Futures Theme, International Livestock Research Institute (ILRI), Nairobi, Kenya and Wageningen University, the Netherlands