Sustainability Assessment of Smallholder Coffee Production Systems in Uganda

Dissertation submitted in partial fulfilment of the requirements for the degree Doctor rerum socialium oeconomiarumque (Dr.rer.soc.oec.)

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# Table of Content

Eidesstattliche Erklärung ....................................................................................................................... iii
Acknowledgement ...................................................................................................................................(iv)
Abstract .................................................................................................................................................. vi
Kurzfassung ............................................................................................................................................... vii

Part I: Framework ........................................................................................................................................ viii

1 Introduction ............................................................................................................................................. 1
  1.1 Problem Statement ......................................................................................................................... 1
  1.2 Research Questions and Structure of the Dissertation ................................................................. 2

2. Literature Review ................................................................................................................................... 3
  2.1 Sustainability Assessment Principles .......................................................................................... 3
  2.2 Conceptual Approaches to Sustainability Assessment .................................................................. 4
  2.2.1 Economic Approaches ............................................................................................................ 5
  2.2.2 Ecological Approaches .......................................................................................................... 6
  2.2.3 Social Approaches .................................................................................................................. 6
  2.2.4 Integrated Approaches .......................................................................................................... 6
  2.3 The SAFA Guidelines and SMART-Farm Tool ........................................................................... 8

3 Methodology .......................................................................................................................................... 11
  3.1 The Research Process .................................................................................................................. 11
  3.2 The Study Context ....................................................................................................................... 11
  3.3 Data and Methods ....................................................................................................................... 13
    3.3.1 Stakeholder Engagement Techniques (Article I) ................................................................. 13
    3.3.2 On-Farm Interviews (Article II and III) .............................................................................. 13

4 Main Results, Discussion and Comparison of Research Articles ......................................................... 14
  4.1 Authorship Statement .................................................................................................................. 14
  4.2 Article I: Stakeholder Engagement in Prioritizing Sustainability Assessment Themes for 
          Smallholder Coffee Production in Uganda .................................................................................. 15
  4.3 Article II: Sustainability performance of certified and non-certified smallholder coffee 
          production in Uganda .................................................................................................................. 15
  4.4. Article III: Group membership and Certification Effects on Incomes Coffee Farmers in Uganda 16

5 Summary and Conclusions ..................................................................................................................... 17
  5.1 Contributions to Scientific Literature .......................................................................................... 17
  5.2 Limitations and Outlook .............................................................................................................. 18

6 References ............................................................................................................................................... 20

Part II: Selected publications .................................................................................................................. 25

Engagement in Prioritizing Sustainability Assessment Themes for Smallholder Coffee Production in Uganda. 
Renewable Agriculture and Food Systems, 32(5):428-445

Sustainability performance of certified and non-certified smallholder coffee farms in Uganda. Ecological 
Economics (under review)

**Article III:** Ssebunya, B.R., Morawetz, U., Schader, C., Stolze, M. and Schmid, E. 2018. Group membership and 
List of Figures

Figure 2. SAFA Dimensions, Themes and Sub-themes ................................................................. 8
Figure 3: The Research Process ................................................................................................. 11
Figure 4: Uganda Coffee Regions and Study Locations ............................................................. 12
Figure 5. The Coffee Value Chain ............................................................................................. 13
Figure 6: Example of Sustainability Map .................................................................................. 19

List of Tables

Table 1: SAFA Guiding Principles .............................................................................................. 4
Table 2: Sustainability Assessment Frameworks .......................................................................... 7
Eidesstattliche Erklärung

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To all my relatives, friends and in-laws, thank you for standing with me!
“The way the world grows its food will have to change radically to better serve the poor and hungry if the world is to cope with growing population and climate change while avoiding social breakdown and environmental collapse”

(IAASTD, 2008).
Abstract

Agricultural production methods need to be continuously improved in order to feed a growing population, utilize natural resources more efficiently and reduce negative effects to the environment. This cumulative dissertation contributes to scientific literature and information demands of stakeholders by analysing and providing recommendations for improving the sustainability of smallholder coffee production systems in Uganda. The dissertation aims at (i) prioritizing sustainability assessment themes for the smallholder coffee production context in Uganda, through stakeholder engagements using the widely-accepted Sustainability Assessments of Food and Agriculture Systems (SAFA) framework, (ii) assessing the sustainability performance of certified and non-certified smallholder coffee production systems, using the indicator-based Sustainability Monitoring and Assessment RouTine (SMART)-Farm Tool, and (iii) econometric estimation of the disaggregated effects of certification and group membership on farm incomes, using sequential g-estimation method. Results show that the structure and scope of the sustainability assessment criteria need to be adapted through contextually-appropriate stakeholder engagements to cope with the social and structural heterogeneity of smallholder production systems. The sustainability performance comparisons show that the certified (organic and or fair trade) coffee production systems perform better than non-certified ones. Certification enhances the achievement of governance goals through its influences on group organization and collective capacities, leading to positive effects on other sustainability dimensions. It is also evident that the structural differences between the production systems have more influence on the sustainability performance than certification per se. This is the case for Arabica production systems that have better sustainability performance than Robusta production systems. Further, the econometric analysis of certification and group membership effects on farm income reveals varying effects depending on the production system. For the long-standing Robusta coffee farmer-groups, no significant effect of certification on net-farm income is observed. But there is 20 percentage points differences in net-farm income between certified and non-certified Robusta farmers explained by membership duration. In contrast, the recently-founded certified Arabica coffee farmer-groups have positive net-farm income effects of 151 percent, partly explained by a higher degree of vertical integration. The results emphasize the importance of group membership, with or without certification, and partly explain the income increasing effect of long-term membership.
Kurzfassung

Part I: Framework
1 Introduction

1.1 Problem Statement

The promotion of sustainable agricultural production systems is growing globally. This can be attributed to the increasing food production costs, heavy reliance on pesticides and fertilizers, fossil fuels, reducing biodiversity, declining soil fertility, water contamination, and food and human safety (Reganold et al., 2001). Initially only environmental concerns were raised due to excessive use of agrochemicals and use of marginal areas for production. Recently, social aspects are receiving increasing attention (Dillon et al., 2008; Lebacq et al., 2013). The goal of agricultural production is no longer simply to improve productivity but to optimize across a far more complex landscape of production, rural development, environmental, social justice and food consumption outcomes (Pretty et al., 2010). In their report about the provision of public goods by agriculture, Cooper et al. (2009) identified rural vitality and farm animal welfare and health as social public goods. The authors stress the importance of social vitality, with agriculture contributing to the achievement of a ‘critical social mass’ required to sustain the services and infrastructure relied upon by rural populations, as well as serving as a repository of skills and knowledge which help to keep alive rural cultures and traditions’.

Management decisions made at the farm level have effects on the individual sub-components of the farm, and can have aggregated effects at village, regional, watershed and landscape levels (van Wijk et al. 2012). Farms naturally play a key role in food production and land use management. Farm management decisions also play an important role around issues related to water use and pollution, soil nutrient depletion, erosion, eutrophication of water bodies, and on an even larger scale the global emissions of greenhouse gases such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) (Vatn et al., 2006). In addition farms, like other businesses, are dynamic with long term transformation processes, which may be induced externally (by market and macroeconomic forces) and/or internally (related to the farmer’s interests and individual aspirations) (Majewski, 2013), for example, the growing concerns among consumers about food safety, the environmental and social consequences of agricultural production (Mergenthaler et al., 2009). Equally the carbon sequestration potential of agro-forestry systems (like coffee) is increasingly seen as an attractive option to combine climate change mitigation with food production (Mutuo et al., 2005).

Various parameters for measuring agricultural sustainability have been proposed by scholars. Although precise measurement of sustainability is not possible, even when specific parameters or criteria are used, it is possible to say whether certain trends are steady, going up or going down (Pretty, 1995). The emphasis of measurement has been put on social, economic, and environmental components. This implies that farming should not only strive for a bottom line with respect to economic performance, but also strive for a bottom line with respect to environmental quality and social acceptance (Elkington, 1994). Hence, appropriate indicators are needed (Hanley, 2000). The underlying question is whether all sustainability pillars are similarly considered when selecting sustainability indicators. Most scholars tend to pay more attention to the environmental impacts of agriculture, and less to the economic and social impacts (von Wirén-Lehr, 2001; Pissourios, 2013). Economic indicators are usually developed with production and market data (Diazabakana et al., 2014), while environmental and social indicators are often based on qualitative assessments. Sustainability indicators should address the multi-functionality of agriculture and should be linked to achievable goals, while involving the stakeholders in the decision making process (Gallopin, 2003). However, engaging stakeholders in sustainability assessment is a challenging endeavor. The diversity of perspectives, derived from different life experiences and cultural backgrounds, tend to undermine consensus around the sustainability indicators (Peterson, 1997). Equally the use of indicators is often difficult due to limitations with data availability and or measurement challenges. Different initiatives exist in literature leading to alternative definitions, goals, scope and scale of measurement. A harmonized but locally adapted sustainability assessment criteria would therefore allow comparison and benchmarking across production systems. Such criteria help to evaluate the effectiveness of a transition toward more sustainable farming systems, while providing improved insight into the effects of prevailing management measures and practices (van Calker et al., 2005). Instead of striving to construct new sustainability assessment methods and approaches, a smart combination of existing ones can result in a sound and useful sustainability assessment. However, the use of existing methods should overcome data and resource limitations while improving accuracy and practicality (van Passel and Meul, 2010). With increasing interest in voluntary sustainability standards (VSS), such criteria can also be used to assess the extent to which certification contributes to sustainability goals at farm-level, supporting consistent policy
and management decisions. While there are many sustainability studies in temperate regions (van Calker et al., 2005), literature on the sustainability of smallholder production systems in the tropics and particularly sub Saharan Africa is hardly available. This dissertation contributes to this knowledge gap by demonstrating the methodological adaptation and application of globally acceptable sustainability assessment criteria to the smallholder context in the tropics.

1.2 Research Questions and Structure of the Dissertation

The aim of this dissertation is to generate knowledge and information required to support stakeholders, such as agricultural experts and policy makers, in science-based decision making, regarding options for improving the sustainability of smallholder coffee production systems. Sustainability assessments are multi-dimensional, transdisciplinary in nature and have been defined and approached differently in varying contexts. Thus this dissertation focuses on analysing and providing options for improving the sustainability of smallholder coffee production systems in Uganda.

Specifically, the following research questions are addressed:

1. Consensus in the definition and measurement of sustainability goals is often challenging as stakeholder needs and interests usually diverge (Bouni 1998). Research question I - what is the appropriate sustainability assessment criteria for smallholder coffee production in Uganda?
2. The assessment of the sustainability of farming systems is commonly challenged by the multiple dimensions and themes to be considered, many indicators and measurement challenges. Research question II - how does the sustainability performance of certified and non-certified coffee farms compare?
3. Both group membership and VSS certification are reported to have positive effects on farm incomes. Research question III - what are the disaggregated effects of VSS certification and group membership on farm incomes?

The research questions are addressed in this cumulative dissertation consisting of two published scientific articles in peer-reviewed journals (Articles I and III) and one submitted article (Article II).

The dissertation is structured as follows. Section 2 presents the main elements of sustainability assessment frameworks, reviewed in the context of applicable literature. Section 3 discusses the research process and empirical methods applied. Section 4 describes the contribution of the author of the dissertation to the research articles, and summarizes the contribution of the articles to scientific literature. Section 5 provides summary, limitations and outlook on future research needs.
2. Literature Review

2.1 Sustainability Assessment Principles

Sustainable development was first described by the World Commission on Environment and Development Brundtland Commission: as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). Building on this, the Food and Agricultural Organization of the United Nations (FAO) further defined sustainable development as “the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (FAO, 1989). As a result, sustainability assessment (SA) has equally attracted many definitions in literature such as:

- “any process that directs decision making towards sustainability” (Bond and Morrison-Saunders, 2011),
- “a tool that can help decision makers and policy-makers decide which actions they should take or should not take in an attempt to make society more sustainable” (Devuyst, 2001), or
- “a process that ensures plans and activities make an optimal contribution to sustainability” (Verheem, 2002).

Despite the wide proliferation of definitions, it remains challenging to operationalize these concepts in different contexts and subjects (Pope et al., 2004). It is value-laden with many dimensions and perceptions, making assessment appraisals often complex. Performing a robust SA requires moving from a mere multi-disciplinary to inter- and trans-disciplinary approaches, while considering cultural and value-based elements (Sala et al., 2015). Thus a robust SA needs to be differentiated from other forms of assessment at ontological, methodological and epistemological levels. As guidance, SA principles have been proposed in sustainability literature. Gibson (2006) proposed that SAs should be comprehensive, address human and ecological effects, encourage positive steps and corrective actions, and ensure multiple gains in a contextually-appropriate way. The BellagioSTAMP (Sustainability Assessment and Measurement Principles) sustainability principles (Pinter et al. 2012) emphasize guided vision, system approach, appropriate scope, conceptual framework and indicators, transparency of data and results, effective communication and stakeholder involvement as key SA principles. The FAO has proposed the Sustainability Assessment of Food and Agricultural systems (SAFA) guiding principles (Table 1). Hence, existing codes available in literature are harmonized and are split between methodological and implementation principles.

Key among the sustainability principles is the need to engage stakeholders in the sustainability assessment process. Effective stakeholder engagement is one of the challenging elements of the SA process (Sala et al., 2015). Even when stakeholders understand and accept the sustainability goals, they may fail to agree on indicators, their measurement and specific trade-offs. Another complimentary key considerations is how to make the sustainability assessment case- and context-specific. Participative engagement of people concerned is one way of making the SA adaptive to the specific case and context. Stakeholder insights, views, hopes, fears, flexibilities, insights and commitments are important contextual factors that influence what changes are feasible in the selected SA framework. Gibson (2006) proposed an approach to contextualizing the SA which starts with desk research drawn from a variety of documentary sources including existing policy and planning documents and prior assessments leading to key priorities and sustainability concerns. The desk research is then complemented with stakeholder engagements deliberating on how the various generic sustainability concerns and goals apply to their context. There are many potentially suitable methods and tools for guiding multi-stakeholder engagements, for example, backcasting scenario-building exercises that help reveal case/context priorities and facilitate depiction of overall objectives and implications (Ravetz, 2000; Robinson, 2003), community mapping (Lydon, 2000; Porter et al., 2002), Nominal Group Technique (Delbecq et al., 1975), or cumulative-effects projections (Cizek et al, 2002; Cizek and Montgomery, 2005). One limitation is that most stakeholder approaches lead to generic results. But a specific combination of the approaches and or expert interviews can lead to discussion of interrelations (synergies and trade-offs) to guide more detailed analysis.

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1 Multidisciplinary implies multiple disciplines that interact only loosely with a shared goal but parallel disciplinary objectives; interdisciplinary implies multiple disciplines that interact closely to achieve a common goal based on a concerted framework; and transdisciplinary implies both close disciplinary interactions and participation from non-academic stakeholders and governmental agencies guided by a common goal (Tress et al., 2005).
Table 1: SAFA Guiding Principles

<table>
<thead>
<tr>
<th>Principles</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methodological</strong></td>
<td></td>
</tr>
<tr>
<td>Holistic</td>
<td>Undertaking an SA addresses all four dimensions of sustainability: good governance, environmental integrity, economic resilience and social well-being and includes all aspects within the sphere and influence of the entity.</td>
</tr>
<tr>
<td>Relevance</td>
<td>SA goals are aligned with globally agreed principles and international reference documents, including Agenda 21 framework and goals.</td>
</tr>
<tr>
<td>Rigor</td>
<td>All SA goals should be in line with the current state of scientific knowledge on the economic, environmental, social and governance impacts of human activities.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>The cost of doing a SA should be minimized by making the best use of existing data from other sustainability, environmental and social management and auditing systems.</td>
</tr>
<tr>
<td>Performance-orientation</td>
<td>Although an SA serves to assess the sustainable performance of an agricultural or food system entity, commitments and management plans alone do not suffice to qualify an entity as sustainable.</td>
</tr>
<tr>
<td>Transparency</td>
<td>The system boundaries, the indicators chosen, data sources and stakeholder relations should be disclosed.</td>
</tr>
<tr>
<td>Adaptability</td>
<td>The SAFA guidelines are generic in nature with a generic set of themes and sub-themes indicators that should be adapted to different socio-economic and environmental circumstances, type of entity and data availability.</td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>SA is not intended as a minimum performance benchmark, also to identify areas for improvement.</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td></td>
</tr>
<tr>
<td>Build on existing tools</td>
<td>Equivalence in different approaches and collaboration is recognized. The SA should be based on rules and principles that emanate from national law and relevant international agreements.</td>
</tr>
<tr>
<td>Take place in an open and learning system</td>
<td>Participation in SA is voluntary and its implementation is in itself a learning pathway to create change and ultimately, deliver sustainability.</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Fair playing field by tailoring requirements to remove barriers to implementation.</td>
</tr>
</tbody>
</table>

Source: FAO, 2014, pg 14-15

2.2 Conceptual Approaches to Sustainability Assessment

Resolving today’s sustainability challenges requires systems thinking\(^2\) to bring thought and behaviour in line with the natural laws of systems behaviour. Systems thinking emphasizes a holistic understanding of the context of farming and rural livelihoods (Nguyen and Bosch, 2013). Bosch et al. (2013) agree that the use of systems thinking helps to leverage sustainability assessment complexities. It involves looking at systems as comprising of individual components that have interdependent linkages with their environment (Bawden, 1995). It therefore allows to define the boundaries of the system under consideration and the hierarchy of aggregation levels; cropping system (plot level), farming system (farm level), watershed/village (local level), landscape/district (regional level), and higher levels (national, supranational, and global level). By identifying the system boundaries, externalities between levels and trade-offs among components can be traced and explicitly taken into consideration (Becker, 1997). In addition to indicating negative interactions of system components and trade-offs among system levels, systems thinking allows to detect and describe synergies among system components (Ikerd, 1993). In economics, methods have been developed to convert such externalities into accountable quantities (Hayati, 2010), and assign “opportunity costs” to trade-off effects.

However applying systems thinking in sustainability assessment can be challenging. This is due to the complexity, interrelatedness, non-transparency, and dynamics of system components leading to feedback mechanisms, cumulative

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\(^2\) Systems thinking is a way to conceptualize and act towards the integration of social, environment and economic dimensions of sustainability aimed at improving the system’s well-being (Nguyen and Bosch, 2013).
effects, time lags, or evolution (Becker, 1997). It therefore requires the development of effective mental models of the relationships between the different parts and hence how sustainability is understood and how it can be achieved (Soderquist and Overakker, 2010). Complementary to systems thinking, sustainability assessment is interdisciplinary, implying that it involves multiple disciplines (contributions from both social and natural science) that interact closely to achieve a common goal based on a concerted framework (Tress et al., 2005). Figure 2 presents an illustration of the interdisciplinary nature of sustainability assessment. The disciplines of ecology, economics, and social sciences are embedded in the governance and policy environment of a society and reflect its underlying ethical and cultural setups (Becker, 1997). The interdisciplinary approach aims to address problems within a context, focusing on adaptive learning and management, on improving situations, involving teams and networks, and accepting that outcomes can be ambiguous, fuzzy or conditional (Jiggins and Gibbon, 1997). If sustainability is to be achieved, understanding the interlinkages between social, ecological and economic dimensions in a systems thinking way is thus of significant importance. This is so because the behavior of a system is in general determined as much by the causal interlinkages between its variables than by the changes in the values of the variables themselves (Gallopin, 2003).

Figure 2. Interdisciplinary Nature of Sustainability Assessment

Source: Author’s illustration

2.2.1 Economic Approaches

Economic approaches focus on human welfare and well-being improving situations within different forms of restrictions. These approaches regard the economy as the relevant system, and nature as the provider of natural resources and services and the sink for the wastes produced by human activities (Pearce and Atkinson, 1992; Turner 1993). Economists usually as advocates of weak sustainability, tend to think that the current generation can leave the future any combination of different capitals as long as the total value of the capital passed on is non-declining (Pearce and Turner, 1990). The weak sustainability criteria asserts that natural and manufactured capital can substitute to some degree. The substitutability of different types of capital implies that the preservation of an aggregate level of natural plus manufactured capital, rather than the preservation of natural capital in particular, is crucial. The Hartwick rule relies on this view. However,

3 The Hartwick rule identifies conditions for infinite constant consumption subject to finite stock of a non-renewable resources.
ecological economists argue that minimum amount of the various forms of capital (ecological, economic and social) should be maintained, recognizing that natural resources are essential inputs in economic production, consumption or reduction of which cannot always be replaced by physical or human capital (van den Bergh, 2007). Under this notion, any development strategy that leads to a reduction of natural capital stocks fails to be sustainable even if other forms of capital increase. Such growth becomes impoverishing rather than enriching (Daly, 1991). Whether the sustainability assessment goal is in pursuit of weak or strong sustainability, it will affect assessment findings and the subsequent advice provided to decision makers. Examples of tools used include cost-benefit analysis, cost-effectiveness analysis, or multi-criteria analysis.

2.2.2 Ecological Approaches

Ecological approaches put emphasis on the respect of the integrity of ecological sub-systems. Ecologists will be typically biased in favour of properties of the biophysical environment, rather than human welfare. This perspective is consistent with the strong sustainability criteria. It asserts that natural resources cannot be substituted by human-made capital - they can be depleted with an irreversible loss in social welfare. It favors a more fundamentalist mode of ecological solidarity with the earth and all forms of life. Since humans depend deeply on the interconnected web of biodiversity for their own survival, Haughton (1999) proposes to prevent the destruction of natural assets beyond their regenerative capacities. Padilla (2002) argues that human beings do not simply have a duty to use nature efficiently, but have obligations to use it with respect, restraint, and an eye toward nurturing its capacity for self-healing. Some environmental components are unique and that some environmental processes may be irreversible (over relevant time horizons). This ecocentric view of sustainability employs the perspective of the donor (ecosystem) during the valuation of the different sustainability issues (Gasparatos et al 2008). Examples of tools used include life cycle assessments (LCA), material flow analysis, resource accounting, ecological footprint, environmental impact assessments (EIA).

2.2.3 Social Approaches

Social approaches focus on people’s overall quality of life, standard of living and well-being, and distributional consequences of decisions that affect individuals, target groups and communities. Social sustainability usually incorporates two concepts – social justice and sustainability of the community. Social justice urges the equitable distribution of resources in society in order to ensure fair access to jobs, housing and local services, while sustainability of community is concerned with the continuing viability and functioning of society as a collective entity (Bramley et al. 2006). Social justice demands attention to social relations, redistribution of rights and resources, and discrimination (Colantonio, 2007). Haughton (1999) argues that social justice is intrinsically connected to environmental justice. Agyeman et al (2002) claims that environmental despoliation and degradation are almost always linked to questions of social justice, equity, rights and people’s quality of life in its widest sense. Examples of tools used include sustainable livelihoods analysis (SLA), and human and social capital measurement.

2.2.4 Integrated Approaches

Integrated approaches are those that take into account interconnections and interdependencies among the single dimensional approaches and foster transdisciplinarity and holism. They are often referred to as ‘three-pillar’ or triple bottom line (TBL) model of sustainability. From this perspective, it is important to assess not only social, economic and environmental implications of actions, but also the interrelations between them. Thus, the key in addressing any sustainability issues is to enhance multiple, mutually reinforcing, fairly distributed, adaptable and lasting contributions to sustainability, while avoiding significant adverse effects. While some trade-offs will inevitably arise, the aim is to reduce them where possible (Gibson, 2006). Transdisciplinary and holistic approaches take the integration of disciplines a stage further through interdisciplinary work that focuses on the connection between more than one branch of knowledge. In fact, ‘transdisciplinary’ connotes a research approach where one not only transcends the boundaries of the disciplines in seeking understanding, but actually generates new concepts and mental structures which subsume and extend the approaches of even an interdisciplinary approach (Proops, 1999). Many integrated approaches have been applied in literature. The DSR (Driving Force-State-Response), for instance, is a flexible framework that has been widely used to better understand the interdimensional linkages of smallholder production systems (OECD, 1999). The DSR framework and its variants have been widely used by prominent organizations such as OECD (1997, 1999, 2001), UNEP (Hardi
and Zdan, 1997), CSD (Mortensen, 1997) and EU-EEA (EEA, 1999). Equally, many sustainability indicator sets have been developed based on this framework (Lenz et al., 2000). However, like many content-based frameworks, it suffers from some weaknesses of partial coverage of sustainability issues, partial capture of the key factors and key processes, and partial reflection of the complex chain of causes and effects (van Cauwenbergh et al., 2007). As a result, other frameworks have been applied in sustainability assessments. Table 2 shows a comparison of the most commonly applied sustainability assessment frameworks. For smallholder settings, the MESMIS is the most widely applied framework for the evaluation of management systems using indicators of sustainability (Astier et al. 2011). The framework has been applied in sustainability evaluation to more than 40 case studies across Europe and Latin America, particularly in Mexico (Speelman et al. 2007). The framework has a holistic approach to sustainability (Lopez-Ridaura et al. 2002). However, in a meta-analysis of 15 MESMIS case study evaluations, Astier et al. (2011) found that the framework explicitly focused on quantifiable indicators, which excluded many important indicators from being incorporated in the evaluation.

<table>
<thead>
<tr>
<th>Framework</th>
<th>Target group</th>
<th>Sustainability attributes</th>
<th>Spatial scale</th>
<th>Use of reference system for thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework for Evaluating Sustainable Land Management (FESLM), (Smith and Dumanski, 1994)</td>
<td>Farmers and other land users</td>
<td>Five pillars: productivity, security, protection, viability, acceptability</td>
<td>Field to large areas</td>
<td>No: thresholds are defined by estimating future trends</td>
</tr>
<tr>
<td>Bossel-framework (Bossel, 2001)</td>
<td>Undefined</td>
<td>Coexisting subsystems and seven basic orientors: existence, effectiveness, freedom of action, security, adaptability, coexistence and psychological needs (human component)</td>
<td>Undefined</td>
<td>Undefined</td>
</tr>
<tr>
<td>Framework for Assessing Natural Resource Management Systems (MESMIS) Lopez-Ridaura et al 2002)</td>
<td>Anyone involved in natural resource systems</td>
<td>Five general attributes of natural resource management systems: productivity; stability, reliability and resilience; adaptability; equity; and self-reliance</td>
<td>From farm to village levels</td>
<td>Yes: cross-sectional or longitudinal comparison of systems</td>
</tr>
<tr>
<td>Sustainability assessment of Farming and Environment (SAFE) (van Cauwenbergh et al., 2007).</td>
<td>Farmers, decision makers, researchers</td>
<td>Three pillars: environmental, social, economic. Ten topics: (environmental) air, soil, water, energy, biodiversity; (economic): viability; (social): food security and safety, quality of life, social acceptability, cultural acceptability</td>
<td>Field, farm, landscape, region</td>
<td>Yes: absolute and relative reference systems</td>
</tr>
</tbody>
</table>

Source: Adapted from van Cauwenbergh et al. 2007

2.3 The SAFA Guidelines and SMART-Farm Tool

In a comparison of the scope and precision of sustainability frameworks and approaches identified in literature, Schader et al. (2014) concluded that none of the approaches served all purposes of sustainability assessment. The Sustainability
Assessments of Food and Agriculture Systems (SAFA) framework developed by the Food and Agriculture Organization of the United Nations (FAO) attempts to close this gap (FAO 2014). The SAFA aims at harmonising sustainability assessments and making methods and results in the food sector more transparent and comparable. By providing a transparent and aggregated framework for assessing sustainability, SAFA seeks to harmonize sustainability approaches within the food value chain as well as guiding good practices. In addition to the social, economic and ecological dimensions considered in many integrated frameworks, SAFA includes an additional ‘governance’ dimension. Each of the SAFA dimensions is made up of multiple themes with different goals (Figure 2).

Figure 2. SAFA Dimensions, Themes and Sub-themes
Source: Adapted from FAO, 2014

Based on the SAFA guidelines, the Research Institute of Organic Agriculture (FiBL) developed an indicator-based Sustainability Monitoring and Assessment Routine (SMART)-Farm Tool. The tool consists of a large pool of indicators from which suitable indicators can be chosen according to the assessment context. In addition to the SAFA Guidelines, the indicators were derived from a review of scientific literature and existing sustainability assessment tools (Jawtusch et al., 2013). The tool operationalizes the SAFA guidelines by defining science-based indicator sets and assessment procedures. For each objective, there is a number of indicators that in combination allow for an assessment of the level of goal achievement, which is expressed on a scale from 0 to 100. Zero (0) represents a state where all applicable farm activities are counteracting the goal achievement, while 100 represents a state where the respective sustainability goal have been fully achieved by
implementing all relevant beneficial activities on a farm and avoiding all relevant detrimental activities to the greatest extent possible. It analyzes the degree of goal achievement with respect to the 58 themes defined in the SAFA framework, using an impact matrix that defines 327 indicators and 1,769 relations between SAFA sub-themes and SMART indicators (Schader et al., 2016).

2.4 Voluntary Sustainability Standards in the Coffee Sector

Coffee is one of the world’s most widely traded agricultural commodities, and the most valuable cash crop in the developing world (Giovannucci et al. 2008). Because of its high importance at both producer and consumer levels, coffee is also the pioneering product for most sustainability standards and certification (Reinecke et al., 2011). Sustainability standards in coffee include Fair trade, Organic, Rainforest Alliance, UTZ Certified, Global GAP, the Common Code for the Coffee Community (4C), Nespresso AAA and Starbucks C.A.F.E. practices, collectively classified as voluntary sustainability standards (VSS).

VSS certification provides credible information to consumers about the attributes of products and supports companies to operationalize their corporate social responsibility commitments (Giovannucci et al. 2014). Some of the prominent sustainability standards in coffee are briefly described next:

- **Fair trade (FT):** One of the earliest attempts to introduce sustainability to commodity trade was the Fair Trade movement. The organized concept of Fair Trade began in the mid-1950s in Europe and entered its current phase in 1988 when it began a new level of expansion and invited mainstream importers, roasters and retailers to participate through the creation of a product-based labelling system (Potts, 2002; Giovannucci & Koekoek, 2003). The objective of FT certification is to support a better life for farmers in the developing world through fair prices, direct trading, community development and environment stewardship. In practice, this is accomplished through two primary mechanisms: a guaranteed minimum price for coffee sold and a price premium that is paid. Founded in 1997, Fairtrade International is a member-based, VSS initiative coordinating FT labelling at the international level. When farmers sell coffee on fair trade terms, the standards guarantee that they will receive at least the fair trade minimum price set for coffee, and an additional premium for investment in community development projects (Fair Trade Foundation, 2012). The decision about how the premium is used must be taken in a democratic manner by the farmers themselves. The FT premium has been used to build schools and health clinics, offer training courses for members of the community, provide educational scholarships, invest in community infrastructure like roads and water systems, conversion to organic production techniques, etc. On the production side, FT certification is open to small farmer organizations that are owned and governed by the farmers themselves and have a democratic decision making structure and transparent administration in place (Fair Trade Foundation, 2012). A separate certification company, FLO-CERT, inspects producers and traders to ensure they comply with fair trade standards.

- **Organic agriculture (OA):** Organic agriculture is a production system that sustains the health of soils, ecosystems and people (IFOAM, 2009). Founded in 1972, the International Federation of Organic Agriculture Movements (IFOAM) is a member-based VSS initiative which sets standards and quality assurance systems for organic production. The objective of organic certification is to create a verified sustainable agriculture system that produces food in harmony with nature, supports biodiversity and enhances soil health. Organic certification is typically determined by standards set at the national or regional level. Many different organic standards may operate within a single country, which may or may not comply with IFOAM global standards. Moreover, local organic standards are increasingly regulated by governments. IFOAM plays a special role in the organic sector as an association of standards, and the initiative unites organic stakeholders, advocates long-term social and ecological change, facilitates production and trade, assists organic development, and provides training (IFOAM, 2009). Generally, organic certification requirements include specific organic inputs, and an internal control system for documentation and record keeping. For farmers using conventional forms of production, a shift to organic farming may entail a need to find new inputs for soil fertility and pest management. For systems that are de facto organic may only need to meet the demands of the certification process. The conversion periods associated with transition to organic agriculture usually range from three to five years.

- **The Rainforest Alliance and Smithsonian Migratory Bird Center:** These VSSs emerged as certifiers of specific social and environmental criteria in the 1990s. The Smithsonian certifies the maintenance of ecologically-sound habitat and
requires compliance with organic principles. While relevant, from a market standpoint it retains a very modest niche. The Rainforest Alliance integrates both biodiversity conservation and social development in its standards and it certifies fruits, cocoa, coffee, forest products (nuts, hearts of palm, vanilla), flowers and ferns, rubber and tea.

- **UTZ Certified**, the Common Code for the Coffee Community (4C), Nespresso AAA and Starbucks C.A.F.E. Practices: UTZ sets basic social and environmental criteria encouraging good agricultural and management practices that are embodied in good agricultural practices for coffee with additional social components. Currently, UTZ certifies coffee, cocoa, tea and hazelnuts (UTZ, 2016). The 4C builds on basic good agricultural and management practices. Its code of conduct intends to eliminate the most unacceptable practices and encourage ongoing improvement. The 4C distinguishes itself from organic, Fair Trade and other schemes by relying on “verification” rather than “certification” of standards compliance. Verification entails an internal monitoring system incorporated within the organizational business model rather than relying on external/third-party verification. Verification of compliance under the 4Cs is now performed in a number of producing countries with the first independently verified coffee emerging in late 2007 (Giovannucci et al. 2008).

In 2004, Starbucks developed with environmental NGO Conservation International its own ethical programme for sourcing coffee, the Coffee And Farmer Equity (C.A.F.E.) Practices, which includes standards related to quality, economic, social and environmental performance. C.A.F.E. Practices promote environmentally responsible growing methods, ensure minimum wages and fair working conditions and advocate for economic transparency and resource management. In 2015, Starbucks achieved a target of sourcing 99% of its coffee ethically, defined as coffee that has been third party audited and verified to be compliant with the company’s C.A.F.E. Practices or Fairtrade standards (Sustainalytics, 2016). Nespresso has a similar approach for its private AAA standard and also focuses on quality. Launched in 2003 in collaboration with the NGO the Rainforest Alliance, the Nespresso AAA Sustainable Quality Program is a green coffee sourcing approach that combines a focus on quality and sustainability. The AAA Program empowers coffee farmers by investing in community infrastructures, paying cash premiums for superior coffee and best agricultural practices, and providing farmers training, financing and technical assistance to continuously improve quality, sustainability and productivity – the three pillars represented by the “triple A” in the program’s name (Nespresso, 2016).
3 Methodology

3.1 The Research Process

Figure 3 illustrates the research process. It is influenced by the approach from Pride and Ferrell (2010) of the five phases of a research process. The first phase is literature review and expert consultations. This phase was helpful in framing the research problem, identifying key stakeholders, and deriving the research questions. This information was crucial in the next stage, conceptual frameworks and sustainability assessment approaches. This stage resulted in the specification of the research design (methods and tools). The next phase is data collection. This involved two stages of primary data collection – coffee stakeholder engagements (research article I) and on-farm assessments (research articles II and III). This led to the next phases of interpreting the data and discussion of findings. The literature review continued to influence the data analysis, interpretation of findings, the conclusions conclusions and recommendations drawn from the findings.

![Figure 3: The Research Process](source: Author’s illustration)

3.2 The Study Context

Uganda produces both Robusta Coffea canephora and Arabica Coffea arabica coffee (Figure 4), of which 90% is produced by smallholder farmers. Arabica coffee is commonly found in the high altitude areas of the eastern, western, and southern regions of the country (USAID-APEP, 2008). Robusta coffee is a native coffee type grown in almost all parts of Uganda. For both coffee types, a number of varieties are found. Robusta coffee can be produced as clonal coffee, a fast maturing and better yielding type (USAID-APEP, 2008). There are significant differences in coffee production systems and the evolution within these systems. These production systems are highly dynamic, co-evolving with their
social, economic, ecological and political contexts (Norman et al., 1994; Collinson, 2000; Dixon et al., 2001). Coffee in Uganda is mostly intercropped with banana, annual crops or trees. Coffee intercropping systems offer more agronomic benefits to smallholder farmers than coffee monocropping systems, with an increase in organic matter and nutrient recycling, soil conservation, productivity life cycle of coffee plants and higher biodiversity values (Moguel et al., 1999). Due to these advantages, there is less need for external inputs in the intercropping system. van Asten et al. (2011) have analysed the agronomic and economic benefits of coffee-banana intercropping in Uganda, showing that coffee yields per hectare and are not significantly affected by intercropping coffee and banana. On the contrary, the coffee-banana intercrop system is more profitable per hectare than having a mono cropping field. Jassogne et al. (2012) also noted that highest coffee yields can be obtained in systems without shade or with low shade levels. However, these same systems represent higher production risks and a higher use of external inputs. In polyculture and forest systems, highest yield quality can be obtained with low use of external inputs, while allowing a better adaptation to climate change, higher carbon stocks, and more ecological services (Jassogne et al., 2012).

Figure 4: Uganda Coffee Regions and Study Locations
Source: UCDA, 2008

The coffee value chain in Uganda is illustrated in Figure 5. At the bottom of the coffee chain are the research institutions developing technologies, which are inputs into the production process. Farmers require land, labour, seedlings, herbicides, pesticides and fertilizers as common inputs for coffee production. These inputs may be provided by non-government organizations (NGOs), government programmes like the national agricultural advisory services (NAADS) and district farmers’ organizations (DFAs) or can directly access them through private agro-input dealers and local coffee nurseries. Most of the coffee is produced by smallholder farmers either in groups, cooperatives or as individuals, but a few large scale coffee plantations exist. Arabica coffee is usually wet-processed, while most Robusta coffee is dry-processed. Some farmer groups or cooperatives may have their own hullers, while majority may outsource the hulling service from private hullers. Farmers may sell dried coffee as individuals at the farmgate directly to local traders (middlemen and/or assemblers) or through the group and cooperatives to exporters and other coffee processors in major trading towns. These domestic or export-oriented millers then perform secondary processing (milling) whereby they clean and grade the coffee according to international standards. The milled coffee is then exported or traded on the domestic to consumers. Some of these exporters or traders are vertically-integrated and managing the respective chains from input-supply to final marketing. Other facilitators like consultants, projects and certifiers play an important value chain facilitation role. They facilitate access to information, new technologies, finance and markets.
3.3 Data and Methods

3.3.1 Stakeholder Engagement Techniques (Article I)

A workshop was conducted following the nominal group technique (NGT) involving a balanced representation of different stakeholder groups. The workshop participants were selected through a consultative process with the National Coffee Stakeholders Platform (NCSP) of Uganda. Each participant independently scored the SAFA sustainability themes, on a Likert scale of 1 to 5 in terms of importance and ease of achievement (feasibility); one being least important (or feasible) and five being most important (or feasible) respectively, in consideration of the smallholder coffee production context in Uganda. Other stakeholders who expressed interest but could not participate in the workshop, were later interviewed as key informants sharing with them feedback from the workshop. Following the workshop, a Delphi process involving a panel of 16 experts was conducted. A Delphi questionnaire was developed from the list of sub-themes generated from the prioritized list of themes. The Delphi questionnaire was distributed by email to all panellists individually, and through the iterative process of individual ratings and comparing of scores, a consensual list of subthemes was generated in round three. The collected data from both the NGT and Delphi processes were further analysed and presented in Article I.

3.3.2 On-Farm Interviews (Article II and III)

Two phases of on-farm interviews were conducted involving the same sample of farms:

(i) The sustainability performance of coffee farms was assessed by individual farm surveys of 362 coffee-producing households in both Arabica and Robusta systems, using a specially-designed farm questionnaire.
The farm questionnaire contained indicators extracted from the adapted SMART-Farm Tool, covering the four dimensions of the SAFA framework. The SMART-Farm Tool comprises a total of 327 indicators, with 1769 linkages between these indicators and the 58 SAFA sub-themes. The indicator set included both qualitative and quantitative indicators and thus with different units. The collected data was manually entered in the SMART-Farm Tool Excel software. In the software, all indicator ratings generated during the interview according to the respective units, are automatically normalized on a scale of 0 to 100%. 0% represents a state where all applicable farm activities are counteracting the goal achievement, while 100% represents a state where the respective sustainability goal have been fully achieved by implementing all relevant beneficial activities on a farm and avoiding all relevant detrimental activities to the greatest extent possible (Schader et al. 2016). This makes it possible to combine both qualitative and quantitative indicators in the analysis. Together with pre-determined impact weights of relevant indicators for respective sub-themes, already built into the tool rated on a scale from -3 to +3 (Schader et al. 2016), the degree of goal achievement by the farm to specific sub-themes is determined. The impacts thus serve as “weights” for the different indicators in assessing the degree of goal achievement for a sub-theme. Thus the SMART-Farm Tool software automatically computes scores per indicator for each farm. The scores were further analyzed and presented in Article II.

(ii) In another structured household data collection exercise, data was obtained for analyzing the certification and group membership effects on farm incomes. Data were collected from 362 coffee households covering both farm and farmer characteristics – farm areas, crops, inputs, coffee specific areas, yields, prices, livestock types, sales, and off-farm income. The questionnaire was administered by a team of enumerators who were trained prior and monitored through the data collection exercise. Collected data were summarized, subjected to econometric analysis and presented in Article III.

4 Main Results, Discussion and Comparison of Research Articles

This section briefly summarises the main research articles which form part of this dissertation. It provides responses to research questions posed in section 1.2 while highlighting the scientific relevance of each article. The contribution of the author of the dissertation to the research articles is described as well.

4.1 Authorship Statement

The author of this cumulative dissertation is the main author of three research articles (I, II and III) published/under review in peer-reviewed scientific journals during the course of the study. The author of the dissertation therefore developed the conceptual background for the research, conducted literature reviews, analysed data, prepared the initial manuscripts for the articles which have been discussed with and complemented by the co-authors.

Article I focuses on stakeholder engagement in the prioritization of sustainability assessment themes for smallholder coffee production in Uganda. The author of the dissertation is primarily responsible for the structure of the article as well as the qualitative and quantitative analyses. Valuable comments from the co-authors contributed to enhancing the quality of the article.

Article II focuses on comparing the sustainability performance of certified and non-certified smallholder coffee farms in Uganda. The author of the dissertation is primarily responsible for the conceptual background and the analyses. Valuable comments from the co-authors contributed to improving the structure and quality of the article. Specifically, the use of the SMART-Farm Tool benefited from valuable discussions with Christian Schader, Lukas Baumgart and Jan Landert (all from the Department of Socio-economics at FiBL).
Article III presents an econometric approach to disaggregating certification and group membership effects on incomes of coffee farmers in Uganda. The conceptual framework and quantitative analyses are main responsibilities of the author of the dissertation with support from all co-authors. The quantitative analyses have been guided by Ulrich R. Morawetz.

4.2 Article I: Stakeholder Engagement in Prioritizing Sustainability Assessment Themes for Smallholder Coffee Production in Uganda.

Article I is published in the journal Renewable Agriculture and Food Systems and demonstrates how to design and implement a stakeholder engagement process for prioritizing sustainability assessment themes for a given production context. The widely accepted Sustainability Assessment of Agricultural and Food systems (SAFA) framework is used to test its applicability for smallholder coffee production systems in tropical context. Although SAFA is regarded universal, applying it in varying production contexts can be challenging.

The wide diversity of stakeholder values and views on how to define and measure sustainability make stakeholder engagement processes critical (Moller and MacLeod, 2013). Different approaches have been proposed from traditional mechanistic to the more deliberative democratic and iterative processes (Mathur et al., 2006) adopted in this article. Coffee stakeholders in Uganda prioritized the SAFA themes according to importance and feasibility for smallholder production following the nominal group technique (NGT). In a Delphi process, stakeholders were further engaged remotely to identify relevant sub-themes. In addition, sustainability barriers and opportunities for the improvement of the coffee sector in Uganda were explored using a system analysis matrix (van Mierlo et al. 2010). As a result, both qualitative and quantitative data were collected supplemented with expert interviews. Accordingly, the article contributes to research question I.

Results show that the structure and scope of some SAFA themes and associated sustainability goals need to be adapted in order to address the social and structural heterogeneity of smallholder production systems. The stakeholders perceived governance and economic themes as most critical for achieving greater sustainability impacts, though equally perceived as most difficult to achieve (least feasible) compared to environmental and social themes. Thus the inclusion of the ‘farmer-group’ structure as part of the Sustainability Assessment Framework for smallholder production was perceived as necessary, as a useful conduit to the achievement of most governance theme goals and sub-theme objectives. 120 themes were prioritized for sustainability assessment of smallholder coffee production, while 33 were recommended for ‘farmer-group’ level assessment. From these themes, measurable indicators can easily be derived to assess and track the progress of certification and other sustainability efforts. From the system analysis, relevant policy and investment strategies for sustainability improvement were identified. Together, the strategies and prioritized themes are useful guides for policy makers and stakeholders for planning and decision making purposes.

The article contributes to scientific literature by providing an approach to defining locally-adapted sustainability assessment criteria, benchmarked on globally-applicable criteria, for tracking and comparing sustainability in diverse production systems. This is a pioneer study testing the applicability of the SAFA framework to the smallholder production context in the tropics. It demonstrates how a global framework can be adapted to local context by engaging stakeholders in a contextually-appropriate way.

4.3 Article II: Sustainability performance of certified and non-certified smallholder coffee production in Uganda

Article II is submitted to the journal Ecological Economics. It presents the comparison of the sustainability performance of certified and non-certified coffee farms in Uganda, using the SAFA-consistent SMART-Farm Tool. The SMART-Farm Tool is used to generate sustainability scores of certified (organic and or fair trade) and non-certified smallholder farms in both Robusta and Arabica coffee production systems. In addition, the synergies and trade-offs between sustainability themes among these farms are analyzed. Hence, the article contributes to research question II.
Many sustainability assessments of agricultural production systems have been developed (Belcher et al. 2004), but they differ in terms of objectives, target audiences, indicators as well as spatial and temporal scales. This study is unique, in terms of applying the four dimensions of sustainability (governance, social, economic and environment), based on the SAFA framework, in comparing the sustainability of smallholder farms in the tropics. It further presents a comprehensive approach to assessing the contribution of certification to sustainability performance of farms. The article therefore contributes to improved understanding of the extent to which production standards and certification contribute to the achievement of sustainability goals. In addition, the interactions (synergies and trade-offs) between sustainability themes were analyzed.

Results show that the sustainability scores of certified farms are significantly higher than non-certified ones. Among the certified categories, the scores of fair trade and organic (FO) are also significantly higher than fair trade (FT) farms. This is consistent with studies which have reported positive impacts of certification on smallholder livelihoods in similar contexts (Altenbuchner et al. 2014; Bolwig et al. 2009; Chiputwa et al. 2015). However, no production system performs well in all sustainability themes. The individual farm scores vary across themes, owing to varied opportunities and challenges that the farms are exposed to. Differences in climatic, institutional, cognitive, or political influences can affect the way coffee is produced. At different levels, sustainability goals can be in direct conflict (NAS 2010). Therefore, the analysis of the relationships between sustainability themes revealed major synergies with the good governance dimension, and trade-offs with the environmental integrity dimension and other dimensions respectively. The extent and distribution of the synergies and trade-offs vary among certified and non-certified farms, but consistent between the production systems. This implies that the differences in the production systems can potentially have more influence on the sustainability performance than the certification per se. Therefore, sustainability-enhancing interventions need to be prioritized depending on the context and status of the farms, while policy can support the transition process to more sustainable systems.

4.4. Article III: Group membership and Certification Effects on Incomes Coffee Farmers in Uganda

Article III is published in the journal European Review of Agricultural Economics and provides a deeper understanding of the VSS certification and group membership effects on farm incomes. Many certification impact pathways reported in literature; directly through higher prices, premiums, and improved quality and production methods or indirectly through effects of group membership. The article analyzes how certification effects on farm incomes are influenced by the duration of group membership of coffee farmers in Uganda. It provides understanding whether certification is necessary to achieve income gains or it is sufficient that farmers organize in groups. Accordingly the article contributes to research question III. Studies have linked certification effects to group membership duration (Jena et al., 2012; Ssebunya et al 2016b), but this has not been done quantitatively. We use sequential g-estimation to test the effect of group membership duration as a mediator for certification, a method originally described for political science (Acharya et al., 2016), but also used in agricultural economic research (Bellemare et al., 2017). The method is intended for cases where the treatment (certification) affects the outcome (farm incomes) through a mediator (group membership duration). The conventional way of simply controlling with an additional independent variable is potentially biased, though in our case this bias is rather small.

Results show that discrepancies in certification effects on smallholder incomes are likely due to unobserved farmer-group heterogeneity. For the long-standing Robusta coffee farmer-groups, we find no significant effect of certification on net-farm income. But, we find 20 percentage points differences in net-farm income between certified and non-certified farms explained by membership duration. The recently-founded certified Arabica coffee farmer-groups have positive net-farm income effects of 151 percent, partly explained by a higher degree of vertical integration. With or without certification, long-standing group membership is found to have positive income effects.
5 Summary and Conclusions

5.1 Contributions to Scientific Literature

Sustainability assessment can be challenging at both conceptual and procedural levels. Conceptualising sustainability requires equal attention to the different dimensions, employment of quantitative and qualitative approaches, identification of trade-offs and reconciliation of the different sustainability goals. Conducting a sustainability assessment requires certain practical decisions or considerations, for example, which entity should carry out the assessment; who, how and at which stages other stakeholders should be involved; how and to whom the assessment results should be communicated; and how the assessment recommendations should be communicated. In doing so, compromises and trade-offs are unavoidable.

Attempts to measure sustainability in agriculture have resulted in many frameworks which vary in scope, objectives and indicators (Schader et al. 2014). The SAFA guidelines were developed by FAO as a global reference in harmonizing the proliferation of SA approaches. As a ‘one-size-fits-all’ approach, its application in different contexts is challenging in terms of selecting and prioritizing contextually-relevant sustainability assessment themes and indicators. In order to live up to its promise of making sustainability assessments comparable, the application of SAFA to varying contexts needs to be tested.

With respect to research question 1 which focuses on identifying contextually-relevant sustainability assessment indicators, this study demonstrates a structured approach to applying the SAFA in the assessment of agricultural production in the tropics, particularly of smallholder farmers. Therefore the results in this article are of academic and practical importance. Specifically the article focused on coffee production, an economically important crop for Uganda; over 3.5 million families live and work on coffee farms and in related support and downstream businesses. The sustainability improvement strategies and prioritized assessment themes are useful to governmental and non-governmental stakeholders for measuring, monitoring and evaluating progress towards sustainable production of coffee in Uganda. Equally the methods used can be applied in other value chains and country contexts.

With respect to research question 2 which relates to comparing sustainability performance, the article sheds more light on the broader contributions of certification to sustainability goals at farm level. Based on the four dimensions of the SAFA framework, results show that no certification (fair trade and or organic) scheme meets all the sustainability objectives at farm level. Although certification generally contributes to better sustainability performance, the study highlights gaps and areas of improvement for all stakeholders involved. However through its influences on group organization and collective capacities, certification contributes to the achievement of governance goals which results in positive effects on other dimensions of sustainability. This creates varied opportunities for strategic sustainability-improvement interventions using the farmer-group as a channel to reach individual farmers.

With respect to research question 3 which relates to the varied impacts of certification and group membership on farm incomes, the article provides a detailed account on the disaggregated effects of group membership and certification on farm incomes. It stresses the fact that certification effects on income depend on the context. Although there was no significant effect of certification on income among Robusta farmers, there were income differences between certified and non-certified farmers explained by differences in membership duration. On the contrary, there were significant differences in incomes between certified and non-certified farmers among Arabica farmers. The article also shows that group membership is directly or indirectly associated with certification of smallholders, it has non-negligible positive effects on income with or without certification. Group membership generates additional income benefits, for example certified groups in both Robusta and Arabica systems operate group saving schemes where members can save and borrow money to invest in alternative income generating activities. Although these benefits may vary with group-specific characteristics, the article proves an income increasing effect of long-term membership.
5.2 Limitations and Outlook

This cumulative dissertation focused on sustainability assessment on farm-level, well aware that often coffee supply chains are longer, extending to farmer-groups (sometimes called primary cooperatives) and the cooperative or export company (secondary level), depending on the context. As a result, sustainability-influencing factors also go beyond the farm level. Therefore, further assessments beyond the farm level (i.e. at both primary and secondary levels) would complement results in this dissertation. Nevertheless, SAFA provides a multi-dimensional approach to sustainability assessment. The framework is, however, still complex in terms of data requirements and interpretation especially for lower level stakeholders to implement and guide decision-making. In addition to the stakeholder engagement process demonstrated in Article I, further efforts are still required to make the framework more user-friendly for a wide range of stakeholders.

The findings show that although the sustainability assessment process can be challenging, it can still be done in a meaningful way to guide decision making. From the comparison of certified and non-certified systems, the findings demonstrate that being ‘certified’ is not enough for sustainability, rather the actual implementation of ‘sustainable’ practices. Although standards emphasize adoption of certain ‘sustainable’ practices before certification, the follow up mechanisms thereafter are equally important. There is a tendency for certification ‘players’ (farmers, managers and certifiers) to become reluctant after they become ‘certified’, thus compromising opportunities for continuous improvement of the entire production system. Building on the collective structures enforced by certification, there are varied un- and under-explored opportunities for stakeholders to intervene through capacity building, advocacy, organizational or infrastructural development to improve the sustainability of smallholder production and overall smallholder livelihoods.

The SMART-Farm Tool approach as a scientific method has intrinsic limitations and specific requirements to deliver credible and consistent results. First, like any survey-based approach, certain prerequisites are needed. Adequate preparation of the audit team cannot be overemphasized. In the SMART-Farm Tool approach, this involves a one-week theoretical and practical on-farm training to ensure proper understanding of the indicators and their application. Currently the SMART indicator set is in English and yet in most cases, assessments are done in local languages. Adequate preparation therefore minimizes the risk that information is lost or misinterpreted during the interview process. The auditors should also have good agricultural educational background or experience to be able to understand the indicator terminology. It is equally necessary that auditors have good understanding of the local context. This is helpful when interpreting indicators that require comparisons with generally accepted local practices and performance benchmarks.

Secondly, with a large set of indicators, the SMART-Farm Tool approach is challenged in terms of efficiency, whereby auditor fatigue can potentially affect the results. Thus the ‘relevance-check’ function of the SMART-Farm Tool is designed to address this limitation. Third, though the SMART-Farm Tool approach is comprehensive, there is an intrinsic trade-off in terms of level of detail in the analysis of some subthemes. For example ‘Energy Use’ and ‘Greenhouse Gases’ can be studied more quantitatively using life cycle assessment method and ‘profitability’ can also be analyzed through detailed calculation of farm incomes and expenditures. Lastly, with limited documentation and record keeping of farm practices at smallholder level, the approach relies heavily on oral responses. This increases the risk of respondent biases especially regarding many governance-related indicators and other self-reported impacts of farm activities on workers’ welfare and neighbouring farms. Therefore complementary interviews with workers, neighbouring farms or other key stakeholders can be helpful to validate farmer responses.

Nevertheless, the SMART-Farm Tool approach provides a rapid way to benchmark farms across farm types and regions at dimension, theme and sub-theme levels (Schader et al. 2016). This contributes to the growing need for rapid sustainability assessment methods that provide results in a cost-efficient manner to support policymaking and decision-making (Ran et al. 2015). The approach is also complementary to other well established tools and methods for measuring resource efficiency quantitatively, e.g. via life cycle assessments. As part of the on-going developments of the tool, a stakeholder-wide validation of the indicator weights has been conducted and the subsequent publication of the findings is underway. In addition, there are on-going efforts to apply the tool in diverse contexts.

To enhance the implementation of the assessment findings at farm level, the research team will conduct dissemination
workshops of the research findings at country (involving members of the National Coffee Stakeholders Platform), cooperative (involving managers and staff of the cooperative societies that participated) and farmer (involving all members of the surveyed farmer-groups) levels. It is anticipated that the dissemination workshops will further stimulate strategies and actions towards improving sustainability issues and gaps highlighted by this study. During the workshops, existing good practices and lessons learnt during the study will be shared. For example, the certified Arabica farmers, who had higher sustainability scores than certified Robusta farmers, had well-crafted visions. The visions highlighted collective goals and aspirations as part of the climate-change project, through which the groups were trained. This exemplifies the importance of the governance dimension in sustainability improvement. As part of the recommendations, farmers need to be motivated to envision their sustainability goals and clearly map-out plans to achieve them, in a simple-but-understandable way (Figure 6).

![Figure 6: Example of Sustainability Map](image)

Such maps are easy to understand by all farmers especially if they are prepared in a participatory way. However, complementary to the maps, clear systems of monitoring progress towards achievement of these plans are required. This shows that beyond awareness, farmers need to be motivated to set realistic and measurable targets (e.g. annual), based on which they can assess the level of achievement of the set sustainability goals. A peer-review mechanism based on farmer-to-farmer visits and on-farm discussions of experiences and challenges, for example farm talks (de Olde et al, 2016), can encourage better compliance to the sustainability targets set at group level. This approach needs to be developed and tested with selected groups, as well as its suitability to different contexts as part of future research. In conclusion, this study emphasizes the need for an integrated (multi-dimensional and multi-stakeholder) approach, if certification is to effectively contribute to its claims of improving the sustainability of smallholder production systems.
6 References


2. Rome.


Part II: Selected publications
Stakeholder engagement in prioritizing sustainability assessment themes for smallholder coffee production in Uganda

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Abstract
Many sustainability assessment frameworks have been developed in recent years, but translating them into practical tools to guide decision making remains challenging. By engaging coffee stakeholders in Uganda, we demonstrate a process of translating the widely-accepted framework for Sustainability Assessments of Food and Agriculture Systems (SAFA), developed by the Food and Agriculture Organisation of the United Nations (FAO), to smallholder production systems. Stakeholders prioritized the sustainability themes in terms of relevance and feasibility, and subsequently identified relevant sub-themes. We find that the structure and scope of some generally accepted themes need appropriate modifications in order to address the social and structural heterogeneity of smallholder production systems. Although importance and feasibility rankings significantly vary within and between stakeholder groups, governance and economic themes are commonly perceived as very important though equally the least feasible for smallholders. Thus, the inclusion of the ‘farmer-group’ structure as part of the sustainability assessment criteria is perceived as necessary especially toward achieving governance-related goals. These findings emphasize the need of engaging stakeholders in defining locally adapted sustainability assessment criteria.

Key words: sustainability themes, SAFA, stakeholder engagement, smallholder production, coffee, Uganda

Introduction
The growing need and interest in measuring, tracking and guiding progress toward achieving sustainability goals has stimulated the development of sustainability assessment approaches (Belcher et al., 2004). Sustainability in agricultural systems incorporates concepts of both resilience (the capacity of systems to buffer shocks and stresses) and persistence (the capacity of systems to continue over long periods), and addresses many wider economic, social and environmental outcomes (Pretty, 2008). However, the definition of sustainability is still a subject of discussions and competing concepts (Lien et al., 2007). The often quoted definition comes from the World Commission on Environment and Development Brundtland report: ‘development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs’ (WCED, 1987). However, it is also believed that individual and societal views of sustainability change over time (Pretty, 1995). With changes emerge new pressures and expectations, and thus new choices to be made. Cornelissen et al. (2001) defined sustainability as an ongoing dynamic development, driven by human expectations about future opportunities based on economic, social and ecological information. Sustainability has become a topic of policy, business and science (Kuhlman and Farrington, 2010); however, consensus in the definition and measurement of sustainability goals is often challenging as stakeholder needs and interests usually diverge (Bouni, 1998). Sustainability measurements should help to evaluate not only the status quo, but also the effectiveness of a transition toward more sustainable farming systems.

Sustainability literature proposes two main approaches in identifying sustainability assessment criteria, i.e.
thus need to be complemented by consultations to define themes and indicators that are closer to the local needs and expectations (Chamaret et al., 2007). In contrast, the bottom-up approaches emphasize user-perspectives in setting goals and establishing priorities, recognizing that the process of identifying sustainability themes and indicators can be as important as their application (Innes and Booher, 1999). Although participatory approaches can generate diverse ideas and insights, there is need to validate some of the results with experts in setting goals and establishing priorities, recognizing that the process of identifying sustainability themes and indicators can be as important as their application (Innes and Booher, 1999). Although participatory approaches can generate diverse ideas and insights, there is need to validate some of the results with experts. Convergence of approaches is being sought in recent studies, for example, van Calker et al. (2005) in dairy farming, Chamaret et al. (2007) in mining, Khadka and Vacik (2012) in forestry, Bal et al. (2013) in construction and Oltean-Dumbrava et al. (2014) in engineering, but lacking for smallholder production systems especially in the tropics.

In this paper, we demonstrate how to design and implement sustainability assessment for smallholder production systems, based on a coffee sustainability assessment project in Uganda. We use the Sustainability Assessment of Food and Agriculture systems (SAFA) framework, developed by The Food and Agriculture Organisation of the United Nations (FAO), which proposes themes, sub-themes and indicators as guides in assessing agricultural sustainability (FAO 2014). We facilitate a stakeholder engagement process to prioritize the SAFA themes according to importance and feasibility for smallholder production. Subsequently, we identify relevant sub-themes, and explore broader sustainability barriers and opportunities for improvement of the coffee sector in Uganda. We apply the nominal group and Delphi techniques to collect both qualitative and quantitative data, supplemented with a system analysis and expert interviews.

The next section describes the SAFA framework, then the data collection process and empirical methods used for stakeholder engagement. This is followed by the presentation and discussion of descriptive and empirical results as well as by conclusions in the last section.

The SAFA Framework

Many sustainability assessment frameworks (SAFs) have been developed in recent years. Schader et al. (2014) conclude that these SAFs vary in scope and precision and no single SAF can serve all purposes of a sustainability assessment. The SAFA, the latest version published in 2014, aims at harmonizing sustainability assessments and making methods and results of sustainability assessments in the food sector transparent and comparable. The framework provides a standard set of sustainability goals, themes, sub-themes and indicators by covering four dimensions—good governance, environmental integrity, economic resilience and social well-being—as well as assessment procedures (FAO, 2014). These dimensions are translated into 21 core sustainability issues or universal themes with associated sustainability goals, which provide a common understanding of ‘sustainability’ in agricultural and food systems. The 21 sustainability themes are detailed into 58 sub-themes, or individual issues within SAFA themes, which are specific to the value chain under article, each with an explicit sustainability objective. The SAFA also defined default indicators within each sub-theme to make the criteria measurable. However, the practical applicability of the SAFA framework still needs to be tested and evaluated under a diversity of conditions (Schader et al., 2012). The SAFA emphasizes that sub-themes and default indicators should be relevant to the circumstances surrounding the entity being assessed. In contrast to the WCED (1987) and OECD (1995) classical SAF, the SAFA also introduced ‘good governance’ as a fourth dimension for farm assessment. However, most themes and sub-themes under this dimension need reinterpretation as they were formulated with respect to larger farms rather than smallholder production systems (Schader et al., 2014).

Coffee Production in Uganda

Uganda produces both Robusta (Coffea canephora) and Arabica coffee (Coffea arabica), of which 90% is produced by smallholder farmers (UCDA, 2012), either in groups, cooperatives or the few large-scale plantations. Arabica coffee is found in the high-altitude areas of the eastern, western and southern regions of the country, while Robusta coffee is a native plant commonly grown in Uganda. The Robusta and Arabica coffee production systems differ and are highly dynamic, co-evolving with the social, economic, ecological and political conditions (Norman et al., 1994; Collinson, 2000; and Dixon et al., 2001). Both production systems are characterized by small farm sizes averaging between 0.5 and 2.5 ha, low coffee yields, aging trees and poor management practices, which make the systems very susceptible to a number of risks including pest and disease outbreaks (UCDA, 2012).

Arabica coffee is usually wet processed, while most Robusta coffee is dry-processed. Farmers may sell dried coffee as individuals at the farm gate directly to local traders (middlemen) or through the group and cooperatives to exporters and other coffee processors. Most of Ugandan coffee is exported, while a small portion is traded on the domestic market. Some traders are vertically integrated and managing the respective chains from input-supply to final marketing. Traders take a central
role in the Uganda coffee value chain especially in terms of quality assurance and certification (UNDP, 2012). Other facilitators such as non-governmental organizations (NGOs) and projects are also important in supporting access to information, new technologies, finance and markets.

Coffee exports are estimated at 3.8 million bags in the 2014/2015 season (GAIN, 2014). According to a study by TechnoServe and IDH/Sustainable Trade Initiative (2013), about 2% of the coffee exports are certified under different sustainability-oriented certification schemes (e.g. organic, fair trade and UTZ). Although the adoption of these certification schemes is growing, there are equally increasing concerns about the multiplicity of certification schemes on the market, seemingly addressing different dimensions of sustainability.

**Data and Methods**

**Stakeholder engagement techniques**

The nominal group technique (NGT) and the Delphi technique were applied to collect data. These were supported by specific interviews with key informants, most of which were recommended by the participating stakeholders. The NGT, developed by Delbecq et al. (1975), is a structured process of generating a large number of ideas from a diverse group pertaining to an issue and prioritizing them accordingly while giving everyone an equal chance to participate in the process. The NGT approach was selected for this paper because it allows direct participant involvement, in a way that is non-hierarchical. Participants have equal voice and all responses to the posed questions have equal validity (Harvey and Holmes, 2012). It is particularly useful for groups in which status differences among participants can inhibit open discussion, as it is in the case of focus groups. In this paper, participants worked in sub-groups to avoid status difference effects. Secondly, the technique is not only helpful to generate a large number of ideas, but also to prioritize these ideas. Thirdly, the NGT is a time efficient method of collecting data, as a session usually takes 1.5–2 h, and participants are only required to attend one session (Potter et al., 2004). This was particularly important considering the diversity of stakeholders involved and the usually limited time for their availability and attention to such engagements. Given the potential limitations of NGT findings, for example, the composition of the group involved (Peña Glasper, 2005), the size of the group (Harvey and Holmes, 2012; and Tuffrey-Weijne et al., 2007), the rigidity and formality of the process (Stewart, 2001) and the time availability (Thomas, 1983), we complemented our NGT findings with a Delphi process. The Delphi process was helpful to generate inputs from other key stakeholders who could not participate in the NGT workshop but agreed to participate remotely.

The Delphi technique is a method for consensus-building during an iterative process using a series of questions to collect data from a panel of selected participants in a remote setting (Dalkey and Helmer, 1963). The technique gives equal weight to each panelist’s judgment thus avoiding power imbalances, influences of dominant individuals, noise and group pressure for conformity (Dalkey, 1972). Panelists are able to adapt their scores based on arguments from the other equally anonymous panelists. However, clarity of the research subject, time frames, the possibility of low response rates, and unintentionally guiding feedback from panelists can be challenges in designing and implementing a successful Delphi (Hsu and Sandford, 2007). Multiple iterations were thus required to achieve consensus. In this paper, the consensus building process for the relevant sustainability sub-themes was done in three rounds.

**The stakeholder engagement process**

The idea of stakeholder engagement echoes back to the first formulation of the ‘stakeholder’ approach by Freeman (1984) who defined a stakeholder as any group or individual who is directly or indirectly affected by a given activity or activities. This can be expanded to include anybody who may have interest in the activity or activities and or the ability to influence its outcome, either positively or negatively. ‘Stakeholder engagement’ is an umbrella term encompassing a range of activities and interactions, including ‘participation’. However, the term ‘participation’ may have many semblances with regard to indicator development (Reed et al., 2005). From Arnstein’s (1969) classic ‘ladder of citizen participation’, several approaches have been suggested to define possible levels or scales of participation. Commonly participation is based on the moral belief that stakeholders should be represented in decision-making processes (Shepherd and Bowler, 1997). However, the level of participation is often influenced by many factors such as who funds or controls the process, the availability of resources, the time scale for outputs to be achieved, the desires and wishes of those involved (Reed et al., 2005) or the characteristics of participants such as number and composition or the nature and duration of the process (Ross et al., 2002) as well as their knowledge and level of organization. Cuellar-Padilla and Calle-Collado (2011) presented eight typologies of participatory models: the participatory approach adopted for this paper belongs to the ‘participation through consultation’. In this type, participation is facilitated through consultation, usually in the form of responses to certain questions, where the method of obtaining information and performing the analysis are both externally defined as it is the case in this paper.

Mathur et al. (2006) argued that a deliberative process of stakeholder engagement starts with the identification of relevant stakeholders, who trust and share values making it easier to align goals and objectives.
Thus, this was conducted in two phases (Fig. 1), a 1-day NGT workshop and a Delphi consultation process involving three steps: (i) stakeholder perceptions on SAFA themes; (ii) identification and mapping of barriers and opportunities for sustainability improvement; and (iii) identification of relevant sustainability sub-themes.

**The NGT workshop**

One effective way to engage with stakeholders is to facilitate a workshop (Kok et al., 2006). We used the workshop, following the NGT, to elicit stakeholder perceptions on the relevance and feasibility of SAFA sustainability themes (Step 1) as well as to identify barriers and opportunities for improving the sustainability of smallholder coffee production (Step 2). The workshop was conducted in January 2015 in Kampala, Uganda. A balanced representation of different stakeholder groups was essential for a proper participatory interaction in the workshop (Haatanen et al., 2014). The list of participants was selected from the National Coffee Platform through a consultative process based on stakeholder expertise, experience or general knowledge of coffee production as well as willingness and availability to attend. The National Coffee Platform is a forum for stakeholders active in Uganda’s coffee sub-sector organized under four pillars (research, extension, farmer organizations, and inputs and credit) to identify strategies for increasing sustainable coffee production in Uganda. The platform has members from government, coffee traders, NGOs, farmer-groups, development partners, input suppliers and stockists, and coffee processors and roasters. For the NGT Workshop, 35 members of the National Coffee Platform were invited, but only 20 members participated representing different stakeholder categories: farmer organization (6) of which three were certified to produce organic, fair trade and UTZ-certified coffee, respectively, coffee companies (3) all dealing in both certified and non-certified coffee, NGOs (4) supporting coffee development, coffee research institutions (4) and government (3) departments of agriculture and trade. The stakeholders who expressed interest but could not participate, were later interviewed as key informants sharing with them feedback from the workshop, while others were invited to participate in the second phase, the Delphi process.

The workshop opened with a general introduction to the purpose of the research as well as providing background information of the SAFA framework and the rules to be followed during the sessions. The participants were split into two groups for purposes of comparing results: practitioners (including farmer leaders, traders and input suppliers) and facilitators (including researchers, NGOs and government). SAFA themes and sub-themes and their respective goals and objectives, were provided to the participants. Using this list, each participant was asked to rate each theme and sub-theme for applicability to smallholder production with 1 or 0 scores to ‘yes’ and ‘no’ responses and related justifications for their respective choices. Though participants were divided into two sub-groups, scoring was done individually, with minimal interactions within sub-groups. All responses were collected, tallied and written on a chart in full view of all groups. This was followed with a validation session to highlight any emerging issues and to ensure that all participants approved the results.

The same process was followed for the ranking of the SAFA themes. In using interval ranking (Churchill, 1999), a ranking sheet was provided where each participant independently scored the sustainability themes, on a Likert scale of 1 to 5 in terms of importance and ease of achievement (feasibility); one being least important (or feasible) and five being most important (or feasible) respectively, in consideration of the smallholder production. To compare the final rankings, the relative importance (and feasibility) weight $w_{ij}$ for theme $i$ and respondent
Prioritizing sustainability assessment themes for smallholder coffee production in Uganda

group \( j \), was calculated (van Calker et al., 2005) as:

\[ w_{ij} = X_{ij} / \sum X_{ij} \]

where \( X_i \) is the average rank of theme \( i \) for respondent group \( j \), and \( X_j \) is the average rankings of all themes for respondent group \( j \). The analysis of variance (ANOVA) was used to compare the consistency of rankings between and within the two sub-groups.

The coffee system analysis matrix

A system analysis matrix is a tool that allows one to link sustainability issues with stakeholder views on opportunities and barriers in transforming toward a sustainable production system (van Mierlo et al., 2010). Hence, the aim of this session was to identify barriers and opportunities beyond the farm-level, which can impact the achievement of sustainability goals and objectives by smallholder coffee farmers. A system analysis matrix has rows, which comprise the key sustainability issues (themes and sub-themes) under each SAFA dimension, and columns which comprise the various stakeholders that perpetuate the system barriers and/or play a part in the creation of sustainability opportunities. Using a system analysis matrix chart (see Appendix 2) pinned-up on the wall, one participant at a time was allowed to either place their post-its or verbally contribute to filling out the matrix. In a validation session, all contributions were filling out the matrix chart (see Appendix 2) pinned-up on the wall, one participant at a time was allowed to either place their post-its or verbally contribute to filling out the matrix. In a validation session, all contributions were

**Results**

**Perceptions on SAFA sustainability themes**

All SAFA themes were perceived as relevant but many require relevant adjustments as indicated in Fig. 2. Generally, stakeholders perceived the SAFA dimensions, themes and sub-themes as comprehensive and good benchmarks for sustainability assessment. However, it was suggested that the structure and scope of some themes and associated sustainability goals need to be adapted while considering the importance of collective action for the sustainability of smallholder production systems. ‘Farmer-groups’ refer to collective action on any agricultural activity along the value chain (Adong et al., 2012). However, there are other terminologies used in literature: producer organizations, farmer organizations, groups of co-operative action. For example, most themes in the good governance dimension were perceived as applicable at ‘farmer-group’ level, while a few sub-themes are relevant at individual-farmer level. Some themes in the social well-being and economic resilience dimensions were also perceived as equally important at ‘farmer-group’ level, for example product quality and information, investment, vulnerability and labor rights.

Varied justifications were provided for the above ratings; accountability and holistic management themes under the ‘good governance’ dimension were perceived to be costly for individual smallholders, rather recommended for the ‘farmer-group’ level; animal welfare, atmosphere and biodiversity under the ‘environmental integrity’ dimension, were perceived as so detailed and yet commonly compliant in smallholder settings. Due to the extensive nature of smallholder production systems with little or no use of synthetic inputs, animal welfare, atmosphere (air pollution) and biodiversity risks are usually seen as not important. All themes under ‘economic resilience’ and the entire ‘social well-being’ dimensions simply require appropriate editing to expand the scope to smallholder production. For example, stakeholders took the view that the entire social well-being dimension needs adaptation to the farmers’ household well-being, not only to workers and community. This is because most smallholder farmers do not employ workers, and if any, only for a short time but they employ family members, which are usually informal and not remunerated.
As a result, several recommendations were made for specific improvements of selected themes, at both individual-farmer and ‘farmer-group’ levels in varying levels of detail. At ‘farmer-group’ level, record keeping, traceability and decision-making processes were recommended to be included in the ‘good governance’ dimension; investment, vulnerability, product information and quality to be included in the ‘economic resilience’ dimension; and labor rights to be included in the ‘social well-being’ dimension for groups employing workers. At farmer level, equally record keeping, traceability and decision-making processes were recommended to be included in the ‘good governance’ dimension; land fragmentation, afforestation and water conservation to be included in the ‘environmental integrity’ dimension; and farmer characteristics (age, education, farming experience, land ownership), household characteristics (size, alternative sources of income), plot characteristics (varieties, crop management measures including pest and disease control) could be included either as part of a new ‘productivity’ theme or together with total revenues and costs of production as part of the profitability sub-theme in the ‘economic resilience’ dimension.

The SAFA themes were ranked for importance and feasibility for the smallholder coffee production in Uganda (Table 1). The average ranking for importance for each theme by each sub-group was computed as the total number of individual rankings, ranging between 1 and 5, averaged over the number of respondents in the sub-group. Corporate ethics (4.82) was ranked as the most important theme under the governance dimension by both sub-groups, however, taking into consideration that it needs to be adjusted to include aspects of leadership, record keeping and traceability. Least was holistic management due to requirements of holistic audits, sustainability management plan and full cost accounting, which as mentioned above were perceived as expensive requirements for most smallholders, and usually taken up by the associated traders or NGO facilitators. It was, however, suggested that if adequately supported, the ‘farmer-group’ can support smallholders to achieve the associated governance goals. Under the environmental integrity dimension, land was ranked as most important (4.88), considering the importance of soil fertility management for the sustainability of coffee production. Though integration of livestock at smallholder level is very important for manure, protein sources and income, the animal welfare theme ranked lowest. This is because as a separate theme, it is geared towards intensive animal production, not common among smallholders. Productivity was recommended as a theme on its own being ranked as the most important economic resilience theme with a score of 5 from both sub-groups. A closely related investment theme was equally ranked very high (4.65) by both sub-groups. The rankings of themes under the social well-being dimension varied widely between the two sub-groups, depending on the perceptions whether farmers’ well-being or the trade relationship with the buyers was most important. It was, however, clear that the fair trading practices theme was ranked most important because it considers both sides, i.e. the farmer and the trader.

On average, good governance themes were ranked highest (4.49) followed by economic resilience (4.43), environmental integrity (4.32) and social well-being (4.22) themes in that order of importance. The respective importance and feasibility weight for each theme in a given dimension, \( w_d \) was computed for each respondent.
Table 1. Importance and feasibility weights of the SAFA themes in respective dimensions.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Themes</th>
<th>Average importance weights, $w_i$</th>
<th>Relative importance weights per dimension, $w_{ij}$</th>
<th>Average feasibility weights, $w_j$</th>
<th>Relative feasibility weights per dimension, $w_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Practitioners ($N = 9$)</td>
<td>Facilitators ($N = 7$)</td>
<td>Practitioners ($N = 9$)</td>
<td>Facilitators ($N = 7$)</td>
</tr>
<tr>
<td>Good governance</td>
<td>Corporate ethics</td>
<td>4.86 (0.38)</td>
<td>4.78 (0.44)</td>
<td>0.23</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Accountability</td>
<td>4.29 (0.76)</td>
<td>5.00 (0.00)</td>
<td>0.20</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Participation</td>
<td>4.29 (0.95)</td>
<td>4.56 (0.73)</td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Rule of law</td>
<td>4.00 (0.82)</td>
<td>4.56 (0.88)</td>
<td>0.19</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Holistic management</td>
<td>4.14 (0.90)</td>
<td>4.44 (0.88)</td>
<td>0.19</td>
<td>0.15</td>
</tr>
<tr>
<td>Environmental</td>
<td>Atmosphere</td>
<td>4.57 (0.79)</td>
<td>4.67 (0.71)</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>integrity</td>
<td>Water</td>
<td>4.71 (0.49)</td>
<td>4.56 (0.73)</td>
<td>0.18</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Land</td>
<td>4.86 (0.38)</td>
<td>4.89 (0.33)</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Biodiversity</td>
<td>3.57 (0.98)</td>
<td>4.44 (0.88)</td>
<td>0.14</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Materials &amp; energy</td>
<td>4.43 (0.53)</td>
<td>4.00 (1.41)</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Animal welfare</td>
<td>3.43 (1.13)</td>
<td>3.67 (1.41)</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Economic resilience</td>
<td>Investment</td>
<td>4.29 (0.95)</td>
<td>5.00 (0.00)</td>
<td>0.25</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Vulnerability</td>
<td>4.29 (0.76)</td>
<td>4.44 (0.88)</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Product quality &amp; information</td>
<td>4.57 (0.53)</td>
<td>4.44 (1.13)</td>
<td>0.26</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Local economy</td>
<td>4.29 (0.95)</td>
<td>4.11 (1.27)</td>
<td>0.25</td>
<td>0.23</td>
</tr>
<tr>
<td>Social well-being</td>
<td>Decent livelihoods</td>
<td>4.33 (0.82)</td>
<td>4.56 (0.73)</td>
<td>0.19</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Fair trading practices</td>
<td>3.67 (0.52)</td>
<td>4.78 (0.67)</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Labor rights</td>
<td>3.17 (0.98)</td>
<td>4.11 (1.17)</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Equity</td>
<td>3.83 (0.98)</td>
<td>5.00 (0.00)</td>
<td>0.16</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Human safety &amp; health</td>
<td>4.50 (0.55)</td>
<td>4.56 (0.73)</td>
<td>0.19</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Cultural diversity</td>
<td>3.83 (0.98)</td>
<td>4.33 (1.12)</td>
<td>0.16</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Figures in parentheses are standard deviations.
...p, which by definition lies between 0 and 1 and the total weights per dimension equals to 1. The ANOVA test revealed that average importance weights varied significantly ($P < 0.05$) between the two sub-groups, but followed consistent trends across the groups.

Cultural diversity, animal welfare and labor rights themes showed the greatest variation in opinions: some participants perceived them as important while others as simply compliant under smallholder settings.

In terms of feasibility for smallholder farmers, most themes ranked average (scores between 2.5 and 3.5) in both sub-groups. This is consistent with the earlier observation that most themes need adaptation to improve their applicability for smallholder production. The ANOVA test revealed that average feasibility weights varied significantly ($P < 0.05$) between and within the two sub-groups. Overall, there was better consistency among importance weights than feasibility weights within the sub-groups.

Following the Delphi process, relevant sustainability assessment sub-themes were identified by consensus in an iterative process. Consistent with the earlier recommendation from the workshop, of the 120 sub-themes selected by the expert panel, 30% were recommended for ‘farmer-group’ assessment, majority of which are good governance themes (Appendix 1). Each sub-theme was described in terms of the specific sustainability objective.

Mapping of barriers and opportunities for sustainability improvement

Using the system analysis matrix, stakeholders identified sustainability issues, barriers and required actions for sustainability improvement (Appendix 2). We summarize these issues, barriers, opportunities and policy strategies in Fig. 3.

The strategies are further described below:

Knowledge development at farmer level: It was perceived that many sustainability-compromising farming practices are still prevalent among coffee farmers. Such practices include deforestation, inappropriate pesticide usage, neglected soil fertility and water management practices. Stakeholders recommended a number of actions geared towards raising awareness and building knowledge of farmers through appropriate training and demonstrations.

Research re-enforcement: It was equally perceived that there are many existing simple and sustainability-enhancing technologies that are not being adopted by coffee farmers. Action research was recommended to appropriately package these technologies in an easy-to-understand way. Specifically technologies associated with productive agroforestry systems, better coffee wet processing and fermentation, integrated pest and nutrient management were highlighted as very important for the sustainability of coffee production in Uganda.

System re-investments: It was widely recognized that one sustainability challenge in coffee production is the limited capacity and desire of farmers to re-invest back into production, postharvest handling and quality improvement at farm level. This has a direct negative effect on future productivity and profitability of coffee production. Stakeholders expressed concern that premiums from certified schemes are no longer a reliable source of funding for farm re-investments as the amount received currently varies widely depending on the sustainability scheme, local market and export market conditions and arrangements.

Coordination between public and private interventions: It was noted that NGOs, private companies and government institutions are running different coffee improvement programs independently. In order to optimize results and improve sustainability, the coordination and harmonization of such programs needs to be improved through public–private partnerships and forums such as the National Coffee Stakeholders Platform.

Harmonized sustainability code: The certification of farmers according to most schemes is commonly financed by NGOs and contracting companies in form of outgrower schemes. The challenge, however, is the need to acquire multiple certifications in order to compete favorably in the market. Besides certification, higher quality was recognized as a key market driver especially for specialty coffee, and yet most standards put little attention to these quality requirements.

Attitudinal and cultural re-orientation: Coffee in Uganda is generally grown in diversified systems, with other food and cash crops as intercrops. Coffee yields are thus far below (<30%) potential due to such management constraints (Wang et al., 2014). Awareness is thus needed on the importance of routine maintenance of coffee gardens to improve yields and ensure sustainability of coffee production.

Farmer institutional support: Over 98% of Uganda’s coffee is grown on small farms (<2 ha) and coffee plots (0.1–1.0 ha). Most of the farmers are organized in groups with 25–30 members with varying capabilities. It was recognized that the sustainability of coffee production will thus depend on the proper functioning of these groups and higher level cooperatives, appropriately negotiating for and representing farmers’ interests.

Discussion

Applying universal sustainability assessment criteria in varying production systems can be challenging. This paper aimed at testing the applicability of the SAFA framework for smallholder production systems in the tropics by facilitating a stakeholder engagement process to prioritize sustainability themes according to importance and feasibility for this specific and...
Prioritizing sustainability assessment themes for smallholder coffee production in Uganda

underexplored context. This is applied to the case of coffee production in Uganda. Consistent with earlier pilot applications (Jawtusch et al., 2013), the SAFA framework provides a useful benchmark for selecting relevant sustainability themes and sub-themes, and makes assessments more comparable (Schader et al., 2014). However, selected themes and sub-themes require appropriate modifications in terms of scope and objectives to suit the smallholder production in the tropics.

Moller and MacLeod (2013) also noted that SAFA is very strong at the generic level, but comparatively weak under specific and local conditions.

Consistent with earlier findings from Rigby et al. (2001) that sustainability can be viewed quite differently, individual opinions about sustainability themes were diverse and varied significantly among the stakeholder sub-groups (practitioners and facilitators). There were, however, more detailed responses from the facilitator sub-group (government, researchers and NGOs), who seemed to have more experience, and certainly influence in studies of this nature. Although, having such ‘experts’ among the stakeholder group was a prerequisite to generate scientifically valid and comparable results, we used two sub-groups to provide an opportunity to the less-experienced participants to share their opinions without pressure from the rest of the group. This is consistent with findings from Reed et al. (2009) and Luyet et al. (2012) who concluded that although methods to measure sustainability should be community-driven, the inclusion of experts is vital to provide a more nuanced understanding of all dimensions of sustainability. This, however, has to be done in an appropriate way to facilitate smooth learning and decision making processes. As a result, the relative weights allocated to the respective themes were significantly different among the sub-groups, but the order of ranking was consistent. In terms of importance, good

Figure 3. Stakeholder perceptions on sustainable coffee production – Issues, Barriers, Opportunities and Strategies.
ability assessment re

some authors argue that it is still important that sustain-

assess in stakeholder processes. Amidst these challenges

requirements. This means that speci

such as organic, fair trade, rainforest or other sanitary

ture and organization are contingent on de

has a highly liberalized but organized coffee value

paradigm) for sub-theme appraisal can be dif

slow, while in other cases stakeholders may be totally un-

can be a very demanding process: responses can be very

Gasparatos and Scolobig, 2012). For example, Uganda

related to sustainability, leading to stakeholder empower-

were involved, provided the opportunity to harmon-

these standards. However, the diversity of stakeholders

the value chain could be biased based on the content of

exceptions (especially practitioners) of sustainability along

Values and views on how to de

focusing on the speci

the indicators versus practicality and (ii) the trade-off

farmer-group (‘business as usual’). Indeed, stakeholder engagement

can be a very demanding process: responses can be very

(c-validity) of

sustainability impacts. However, these were equally per-

pragmatic way that promotes smallholders’ resilience to

sustainable Trade Initiative, 2013), or attitudinal change

and farmer institutional support (Hazell and Wood,

2008; Godfray et al., 2010). Such strategies are critical

to address the identified sustainability challenges in a

stakeholders may prefer to perpetuate the status-quo

themselves. For example, Uganda

so that sustainability assessment criteria for tracking and

comparing sustainability in diverse production systems. We used the SAFA framework as a widely accepted

benchmark, testing its applicability to smallholder pro-
duction in the tropics, using the case of coffee production

in Uganda. From the results, we draw the following con-

clusions: (1) Although some sustainability themes, such as

in SAFA, are considered universal, their structure and

scope as well as related goals still require adaptation in

order to address the social and structural heterogeneity of

smallholder production systems. The adaptation can be

done by engaging stakeholders in a contextually appro-

priate way, for example, through an innovative combin-

ation of applicable participatory approaches as

demonstrated in this paper. (2) The prioritization of sus-

tainability themes and identification of relevant sub-

themes depends on which stakeholders are involved and

how they are engaged in the process. We find that a hetero-
genous group of stakeholders is needed, and where pos-
sible, utilizing sub-groups, key informants or experts to

compare consistency of findings. For the smallholder pro-
duction, stakeholders perceived governance and econom-
ic themes as most critical for achieving greater sustainability impacts. However, these were equally per-

ceived as most difficult to achieve (least feasible) com-
pared to environmental and social themes. (3) The

inclusion of the ‘farmer-group’ structure as part of the

SAF for smallholder production was perceived as neces-
sary. Experts believed that the group structure is a

useful conduit to the achievement of most governance

theme goals and sub-theme objectives in many value

chains involving smallholders. As a result of the 120

sub-themes identified for sustainability assessment of

smallholder coffee production, 33 were recommended

for ‘farmer-group’ level assessment. Based on these

results, measurable indicators can easily be derived, to

assess and track the progress of certification and other

sustainability efforts. (4) By integrating a system analysis,

the understanding of the sustainability agenda improved

among stakeholders. As a result, relevant policy and in-

vestment strategies for sustainability improvement were

derived from the identified system barriers and opportu-
nities. The strategies are useful guides for policy makers

and stakeholders for planning and decision making pur-

poses. The findings presented in this paper are based on

the smallholder coffee production in Uganda, however,

the methods are applicable to other value chains and

countries.

Conclusions

This article contributes to the need for locally-adapted sustainability assessment criteria for tracking and

Acknowledgements. The authors thank Harriet Fowler of Café

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Platform—Uganda for their contributions. The funding of this paper was made available by The funding of this paper was

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Frick, Switzerland the Research Institute of Organic

Agriculture (FiBL), Frick, Switzerland.
Prioritizing sustainability assessment themes for smallholder coffee production in Uganda

References


## Appendix

Table A1. List of sustainability sub-themes and respective objectives at both farm and group levels.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-theme</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group level (33)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good governance (14)</td>
<td>Record keeping</td>
<td>All records and documents that relate to group activities exist and kept for at least 1 year</td>
</tr>
<tr>
<td></td>
<td>Leadership structure</td>
<td>The group has a functioning management structure, indicating the roles of all group leaders</td>
</tr>
<tr>
<td></td>
<td>Democracy &amp; transparency</td>
<td>Leaders are elected in a democratic and transparent way, involving all members</td>
</tr>
<tr>
<td></td>
<td>Internal control system</td>
<td>An internal system exists that formally inspects members compliance to the Code of Conduct</td>
</tr>
<tr>
<td></td>
<td>Internal communication</td>
<td>An effective system of disseminating and receiving information from members exists</td>
</tr>
<tr>
<td></td>
<td>Social or environmental impacts</td>
<td>Group has not been blamed of negative impacts on humans or the environment</td>
</tr>
<tr>
<td></td>
<td>Conflict resolution</td>
<td>There were no unresolved conflicts in the last 2 years among the members within the group</td>
</tr>
<tr>
<td></td>
<td>Compliance with the law</td>
<td>There have been no cases in which the group has violated the law</td>
</tr>
<tr>
<td></td>
<td>Commitment to sustainability</td>
<td>Group is aware and committed to the principles of sustainability as part of its mission</td>
</tr>
<tr>
<td></td>
<td>Training of members</td>
<td>Group members are trained on an on-going basis</td>
</tr>
<tr>
<td></td>
<td>Strategic planning</td>
<td>The group has a strategic plan for future activities addressing key sustainability requirements</td>
</tr>
<tr>
<td></td>
<td>Sustainability plan</td>
<td>The group has a written or verbal plan of required improvements in its sustainability</td>
</tr>
<tr>
<td></td>
<td>Community participation</td>
<td>Group supports or takes part in community activities or projects for improving sustainability</td>
</tr>
<tr>
<td></td>
<td>Policy engagements</td>
<td>Group supports or takes part in advocacy or social activities for improving regulations/laws</td>
</tr>
<tr>
<td>Economic resilience (8)</td>
<td>Compliance to sustainability</td>
<td>Group is organic, fair trade, UTZ, 4Cs, rainforest certified or involved in any sustainable programs</td>
</tr>
<tr>
<td></td>
<td>Quality management</td>
<td>The group complies with quality requirements during storage, handling or processing of its products (including coffee)</td>
</tr>
<tr>
<td></td>
<td>Value addition</td>
<td>The group adds value to its products (including coffee) for example in form of processing before selling</td>
</tr>
<tr>
<td></td>
<td>Traceability</td>
<td>The origin of member products is completely traceable</td>
</tr>
<tr>
<td></td>
<td>Storage facilities</td>
<td>Storage facilities and equipment kept clean, pest and water leak proof</td>
</tr>
<tr>
<td></td>
<td>Financing</td>
<td>The group has alternative sources of money to finance its activities</td>
</tr>
<tr>
<td></td>
<td>Group savings</td>
<td>The group is involved in a savings program or scheme</td>
</tr>
<tr>
<td></td>
<td>Collective marketing</td>
<td>The group sells its products (including coffee) collectively on behalf of its members</td>
</tr>
<tr>
<td>Social well-being (9)</td>
<td>Women engagement</td>
<td>The group encourages women participation and equitably recognizes women’s contribution</td>
</tr>
<tr>
<td></td>
<td>Youth engagement</td>
<td>The group encourages participation of the youth and equitably recognizes their contribution</td>
</tr>
<tr>
<td></td>
<td>Transparency in premium use</td>
<td>Members are aware, receive and participate in decision making on premium use</td>
</tr>
<tr>
<td></td>
<td>Training of workers</td>
<td>A large proportion of the workers have access to training on a regular basis</td>
</tr>
<tr>
<td></td>
<td>Working conditions</td>
<td>All workers are working under mutually agreed employment terms</td>
</tr>
<tr>
<td></td>
<td>Forced labor</td>
<td>The group is not involved any forms of forced labor (including use of prisoners)</td>
</tr>
<tr>
<td></td>
<td>Child labor</td>
<td>Children below 16 years perform their work for the group in a way that their school performance is not impaired by that work or hazardous to their health or development</td>
</tr>
<tr>
<td></td>
<td>Mechanization</td>
<td>The physical workload is reduced and replaced with appropriate mechanization</td>
</tr>
<tr>
<td></td>
<td>Use of personal protective gear</td>
<td>The group ensures that workers have appropriate protection from hazardous materials</td>
</tr>
<tr>
<td>Environmental integrity (2)</td>
<td>Air &amp; water pollution</td>
<td>The group has mechanisms to minimize potential air and water pollution arising from its coffee handling activities, for example through proper storage of pesticides kept at group level</td>
</tr>
<tr>
<td></td>
<td>Proper waste disposal</td>
<td>All forms of waste (organic and inorganic) are appropriately disposed</td>
</tr>
</tbody>
</table>
### Farm level (87)

#### Good governance (8)
- **Record keeping**: All records and documents that relate to farm activities are kept for at least 1 year.
- **Commitment to sustainability**: The farmer is aware and committed to the principles of sustainability as part of its mission.
- **Social or environmental impacts**: The farmer has not been blamed of negative impacts on humans or the environment.
- **Communication within farm**: Important decisions are taken in consideration of the rest of the household and neighbors.
- **Compliance with the law**: There have been no cases in which the farm has violated the law.
- **Use of risky technologies**: The farm does not use genetically modified organisms or other technologies with unknown risks.
- **Use of prohibited pesticides**: The farm does not use prohibited chemicals nor pesticides.
- **Involvement in community projects**: The farmer supports or takes part in social and/or environmental community projects.

#### Economic resilience (36)
- **Land ownership status**: The farmer has undisputed legal rights of over the farm land including coffee acreage.
- **Compliance to sustainability standards**: The farm is organic, fair trade, UTZ, 4Cs, rainforest certified or any sustainable coffee program.
- **Collective marketing**: The farmer sells coffee collectively with other farmers as a group.
- **Relationship with current buyers**: The farm has a stable relationship with existing customers/buyers.
- **Diversification of markets**: There are alternative markets for its products (including coffee) if current buyers drop out.
- **Access to market information**: The farmer has full access to market information whenever it is needed.
- **Farm savings potential**: The farm has adequate savings to cater for its cash needs.
- **Access to credit potential**: The farm has access to credit to meet its financing needs.
- **Extent of farm debt**: The farm's extent of borrowing is significantly low as compared to the total farm capital.
- **Supply of farm inputs**: A large portion of farm inputs comes from reliable suppliers with stable long-term relationships.
- **Yields compared to regional level**: The yields of the farm's main products (including coffee) are higher than regional averages.
- **Extent of postharvest losses**: The farm experiences very minimal postharvest losses.
- **Extent of food wastages**: Zero or only a small portion of the farm products (including coffee) are disposed of.
- **Further training of the farmer**: The farmer invests in his/her further training.
- **Investment in farm improvement**: The farm invests into long-term improvements of the farm (for example, buildings, machines, roads, land).
- **Average product prices**: The farm receives significantly higher prices than the average market prices.
- **Average farm revenues**: The farm receives significantly higher revenue than average regional farm revenues.
- **Average cost of production**: The costs of production is significantly less than the regional average costs.
- **Average farm profits**: The farm's net profits are significantly higher than average regional farm profits.
- **Profit stability**: The farm's profit has been rising or stable in at least the last 2 years.
- **Income diversification**: The farmer has additional sources of on and off farm income besides farming.
- **On farm value addition**: The farm is involved in some of value addition to its products (including coffee) before selling, e.g. milling.
- **Crop (coffee) acreage**: The farmer has commercially viable acreage for its main crops (including coffee).
- **Maintenance of crop (coffee) gardens**: Heavy pruning, training, stumping and/or replanting are performed to promote an optimal yields of main crops (including coffee).
- **Product rejects or returns**: No product (including coffee) has been rejected or returned by buyers in the last 2 years.
- **Quality of products**: A big proportion of farm products (including coffee) are sold as first grade.
- **Harvesting methods**: Only appropriately ripe crops (including coffee) are harvested using the best methods for optimizing quality and crop health.
- **Pesticide residues control**: Crops are harvested after adequate pre-harvest intervals after pesticide application.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-theme</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage practices</td>
<td>Storage facilities are kept clean, pest and water leak proof, with good ventilation, stored off-ground, away from the walls and not together with chemicals</td>
<td></td>
</tr>
<tr>
<td>Climate change adaptation</td>
<td>The farmer is aware and has plans to adapt to the possible consequences of climate change</td>
<td></td>
</tr>
<tr>
<td>Production and market challenges</td>
<td>The farmer is aware and prepared for future agricultural production and market challenges</td>
<td></td>
</tr>
<tr>
<td>Disaster preparedness</td>
<td>The farm is adequately prepared for any other natural or manmade disasters (theft, fire, etc.)</td>
<td></td>
</tr>
<tr>
<td>Access to advisory services</td>
<td>The farmer has adequate access to advisory services</td>
<td></td>
</tr>
<tr>
<td>Farm succession plan</td>
<td>Farm succession is secured in the event of the farmers’ death or divorce</td>
<td></td>
</tr>
<tr>
<td>Stability of labor</td>
<td>The farm has not experienced labor shortages in the last 2 years</td>
<td></td>
</tr>
<tr>
<td>Cooperation with other farmers</td>
<td>The farmer cooperates with other farmers</td>
<td></td>
</tr>
<tr>
<td>Environmental integrity (35)</td>
<td>A large portion of the farm land is under agro-forestry systems</td>
<td></td>
</tr>
<tr>
<td>Crop rotation</td>
<td>A planned crop rotation for arable crops is practiced by farmers</td>
<td></td>
</tr>
<tr>
<td>Crop varieties</td>
<td>Indigenous crop and tree varieties are encouraged and grown on the farm</td>
<td></td>
</tr>
<tr>
<td>Area covered with wood/timber</td>
<td>A portion of the farm’s area is covered by wood/timber, not removed over the past 5–10 years</td>
<td></td>
</tr>
<tr>
<td>Use of renewable energy</td>
<td>A large portion of the energy consumed is derived from renewable resources</td>
<td></td>
</tr>
<tr>
<td>Inorganic waste disposal</td>
<td>Inorganic waste (batteries, old clothes/shoes, broken utensils, etc.) is appropriately disposed</td>
<td></td>
</tr>
<tr>
<td>Recycling of inorganic waste</td>
<td>A large portion of inorganic household and farm waste is recycled</td>
<td></td>
</tr>
<tr>
<td>Extent of herbicide use</td>
<td>A small portion of the farm area receives synthetic herbicide applications</td>
<td></td>
</tr>
<tr>
<td>Extent of fungicide use</td>
<td>A small portion of the farm area receives synthetic fungicide applications</td>
<td></td>
</tr>
<tr>
<td>Extent of insecticide use</td>
<td>A small proportion of the farm area receives synthetic insecticide applications.</td>
<td></td>
</tr>
<tr>
<td>Safe use of pesticides</td>
<td>All equipment used to apply pesticides is maintained in good condition, pesticide residues or containers properly disposed off and pesticides properly stored to minimize contamination risks</td>
<td></td>
</tr>
<tr>
<td>Use of clean planting materials</td>
<td>Seeds and planting materials are obtained from sources, free of visible signs of pest and disease</td>
<td></td>
</tr>
<tr>
<td>Use of resistant varieties</td>
<td>Suitable varieties are used which are resistant to common pests and diseases</td>
<td></td>
</tr>
<tr>
<td>Weed management</td>
<td>Weeds are controlled to optimize nutrient and water uptake as well as spread of pests and diseases.</td>
<td></td>
</tr>
<tr>
<td>Area under mulching</td>
<td>A large portion of the farm area is mulched</td>
<td></td>
</tr>
<tr>
<td>Area under legume crops/trees</td>
<td>A large portion of the farm’s area is covered by leguminous cover crops</td>
<td></td>
</tr>
<tr>
<td>Area under conservation farming</td>
<td>A portion of the land is subject to no/zero or minimum tillage (conservation farming)</td>
<td></td>
</tr>
<tr>
<td>Area under green manures</td>
<td>Green manures are used as part of the crop rotation or live mulch in perennials crops</td>
<td></td>
</tr>
<tr>
<td>Soil water harvesting</td>
<td>Measures to reuse crop residues are employed</td>
<td></td>
</tr>
<tr>
<td>Use of crop residues</td>
<td>When determining chemical fertilizer requirements, either soil analysis or other reference is used to avoid excessive application</td>
<td></td>
</tr>
<tr>
<td>Needs based fertilizer use</td>
<td>Farm yard manure or compost is used.</td>
<td></td>
</tr>
<tr>
<td>Amount of manures or compost</td>
<td>Untreated human sewage, sludge, and sewage water are not used for crop production on the farm</td>
<td></td>
</tr>
<tr>
<td>Use of untreated human sewage and sludge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td><strong>Animal manure storage</strong></td>
<td>Animal manure used as fertilizer is stored at least 25 m away from any water body</td>
<td></td>
</tr>
<tr>
<td><strong>Area under mineral fertilizers</strong></td>
<td>A relatively small portion of mineral fertilizers is used</td>
<td></td>
</tr>
<tr>
<td><strong>Soil erosion control</strong></td>
<td>Adequate measures are taken to combat soil erosion (for example, terracing, trenches, contour planting, etc.)</td>
<td></td>
</tr>
<tr>
<td><strong>Extent of land/soil degradation</strong></td>
<td>No portion of the farm area has been rendered unproductive (degraded)</td>
<td></td>
</tr>
<tr>
<td><strong>Use of wetlands for cultivation</strong></td>
<td>The farmer refrains from draining and cultivation in wetlands</td>
<td></td>
</tr>
<tr>
<td><strong>Water availability and quality</strong></td>
<td>The farm has year-round adequate access to water and of good quality</td>
<td></td>
</tr>
<tr>
<td><strong>Re-use of wastewater</strong></td>
<td>Some of the wastewater arising on the farm is re-used</td>
<td></td>
</tr>
<tr>
<td><strong>Disposal of wastewater</strong></td>
<td>Bad quality wastewater arising on the farm is always correctly discharged</td>
<td></td>
</tr>
<tr>
<td><strong>Use of rainwater</strong></td>
<td>Rainwater is collected and used</td>
<td></td>
</tr>
<tr>
<td><strong>Use of irrigation</strong></td>
<td>The farm is able to supplement crop water requirements through irrigation</td>
<td></td>
</tr>
<tr>
<td><strong>Water storage capacity</strong></td>
<td>Sufficient capacities exist for water storage on the farm</td>
<td></td>
</tr>
<tr>
<td><strong>Air pollution</strong></td>
<td>The farmer refrains from open burning of bushes, crop residues and household/farm wastes or other forms of air pollution</td>
<td></td>
</tr>
<tr>
<td><strong>Social well-being (8)</strong></td>
<td>A large proportion of the workers have access to training opportunities</td>
<td></td>
</tr>
<tr>
<td><strong>Training of workers</strong></td>
<td>All workers are working under mutually agreed employment terms</td>
<td></td>
</tr>
<tr>
<td><strong>Employment terms/contracts</strong></td>
<td>The farmer is not involved in any forms of forced labor (including using prisoners)</td>
<td></td>
</tr>
<tr>
<td><strong>Forced labor</strong></td>
<td>Children below 16 years perform their work for the farmer in a way that their school performance is not impaired by that work or hazardous to their health or development</td>
<td></td>
</tr>
<tr>
<td><strong>Child labor</strong></td>
<td>Workers have access to clean drinking water and food during working hours</td>
<td></td>
</tr>
<tr>
<td><strong>Working conditions</strong></td>
<td>The physical workload on the farm is reduced due to the degree of mechanization on the farm</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanization</strong></td>
<td>Workers have appropriate protection during their application of hazardous materials</td>
<td></td>
</tr>
<tr>
<td><strong>Use of personal protective gear</strong></td>
<td>All members of the household obtain adequate quantity of nutritious food each day</td>
<td></td>
</tr>
<tr>
<td><strong>Household food security</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. A2. Coffee system sustainability analysis matrix. Legend: YELLOW OVALS – Sustainability Barriers; WHITE OVALS – sustainability-enhancing Interventions; GREEN BOXES – Sustainability Strategies.
Sustainability Performance of Certified and Non-certified Smallholder Coffee Farms in Uganda

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2Department of Economics and Social Sciences, University of Natural Resources and Life Sciences (BOKU), Feistmantelstrasse 4, 1180 Vienna, Austria

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Abstract: The transition toward sustainable agricultural production can be supported with improved insight into the performance of existing farming systems. The Sustainability Assessments of Food and Agriculture Systems (SAFA) framework published by the Food and Agriculture Organisation (FAO) provides a comprehensive and harmonized framework to assess and compare farming systems. We use the indicator-based SAFA consistent Sustainability Monitoring and Assessment RouTine (SMART) Farm Tool to analyze and compare the sustainability performance of certified organic and fair trade as well as non-certified smallholder farms in Uganda. We further analyze the synergies and trade-offs between sustainability themes using the non-parametric Spearman correlation test. We find that certification is associated with improved sustainability performance of smallholder coffee farms. It enhances the achievement of governance goals through its influences on group organization and collective capacities, resulting in positive effects on other sustainability dimensions. Major synergies were observed with the good governance dimension, and trade-offs with the environmental integrity dimension and other dimensions respectively. Although the extent and distribution of the synergies and trade-offs vary among farms, they are consistent within the production systems – implying that the structural differences between the production systems have more influence on the sustainability performance of farms than certification per se.

Keywords: SAFA, SMART, Coffee, Sustainability, Certification, Uganda
1. INTRODUCTION

Coffee is one of the world’s most widely traded agricultural commodities and the most valuable cash crop for many developing countries (Giovannucci et al. 2008). Coffee is also a pioneering product for sustainability standards and certification (Reinecke et al. 2011). Sustainability standards in coffee include Fair trade, Organic, Rainforest Alliance, UTZ Certified, Global GAP, the Common Code for the Coffee Community (4C), Nespresso AAA, and Starbucks C.A.F.E. practices. Certification according to these standards provides credible information to consumers about the attributes of the coffee product and its producers. As a result, certification helps companies to operationalize their corporate social responsibility commitments (Giovannucci et al. 2014). Certification is also widely used to define best practice in primary production, processing and trading of agricultural products. It is typically adopted voluntarily and paired with specific labels to differentiate certified from non-certified products in the marketplace (Milder 2013). Despite the growing popularity of certification, there are contradicting reports on the impacts of these certified systems to various elements of sustainable livelihoods. In Uganda, about 1.7 million smallholder farmers produce coffee and about 10% of the coffee is certified under different standards (UCDA 2012). In a study to analyze and compare impacts of three certification standards – Fair trade, Organic, and UTZ – on the livelihoods of smallholder coffee farmers in Uganda, it was concluded that fair trade certification increases household living standards by 30% and reduces the prevalence and depth of poverty (Chiputwa et al. 2015). Certified organic coffee production has also been reported to contribute to higher farm revenues in Uganda (Bolwig et al. 2009). However, none of these studies consider all main aspects of sustainability simultaneously.

Many sustainability assessment approaches have been developed (Belcher et al. 2004), but most of them are usually challenging in defining what-is-sustainable (Lien et al. 2007). This is in the context of sometimes conflicting societal goals and heterogeneous impacts of production systems due to stochastic processes and social specificities (Ikerd 1993). A common ground of sustainability assessments is seen in a solid conceptual and methodological basis to support empirical analysis. Assessments not only provide a benchmark for the production systems under consideration but also provide guidance for decision makers in revealing impacts and trade-offs of particular measures. Sustainability assessments also provide evidence on effects of management measures and farming systems on individual sustainability aspects and overall sustainability (van Calker 2005). Whether ex-ante or ex-post, sustainability assessments of agricultural production systems require a combination of different models and methods in order to deliver useful information about the impacts of proposed changes in the systems (Thornton and Herrero 2001). Sustainability assessment approaches differ in a number of aspects including the general objectives, target audiences, issues addressed and indicators selected as well as the spatial and temporal scales covered (Ran et al. 2015). The MESMIS framework has been applied in agricultural sustainability evaluation to more than 40 case studies across Europe and Latin America (Speelman et al. 2007). The framework is built upon four principles: (i) sustainability is defined by seven dynamic, systemic attributes: productivity, stability, reliability, resilience, adaptability, equity and self-reliance; (ii) sustainability evaluations are only valid for a specific management system on a specific spatial and temporal scale; (iii) the evaluation process is participatory to capture diverse opinions; and (iv) sustainability is assessed through the comparison of systems either simultaneously or throughout time (Lopez-Ridaura et al. 2002). However, the framework explicitly focuses on quantifiable indicators, which excludes many important indicators from being incorporated in the evaluation (Astier et al. 2011). In a detailed comparison of the scope and precision of different approaches identified in literature, Schader et al. (2014) concluded that no single approach serves all purposes of sustainability assessment. The Sustainability Assessments of Food and Agriculture Systems (SAFA) guidelines were developed by the Food and Agriculture Organization of the United Nations to close this gap (FAO 2014). The guidelines aim at harmonising sustainability assessments and making methods and results of sustainability assessments in the food sector more transparent and comparable. Each of the SAFA dimensions is made up of multiple themes and sub-themes with different sustainability objectives (Annex 1).
Based on the SAFA guidelines, the Research Institute of Organic Agriculture, FiBL, developed an indicator-based multi-criteria assessment tool called Sustainability Monitoring and Assessment RoutTine (SMART) Farm Tool (Schader et al. 2016). The tool consists of a large pool of indicators to support trade-off and synergy analysis. The tool operationalizes the SAFA guidelines by defining science-based indicator sets and assessment procedures derived from a review of scientific literature and existing sustainability assessment tools. For each SAFA sub-theme, there are a number of indicators that allow for an assessment of the level of goal achievement with respect to the 58 themes defined in the SAFA guidelines (see Annex 1).

Given the multiplicity and interlinkages between sustainability goals, it is apparent that some goals can be mutually reinforcing (synergies) while others compete (trade-offs) in pursuit of sustainability (Jackson-Smith 2010). For example trade-offs can arise between food for the household versus expanding area under cash crop production. Equally there is a desire to use production practices that protect soil, air, water, and biological resources versus applying synthetic pesticides and fertilizers that can have adverse effects to human and ecosystem health (Reganold et al. 2001). Hence, revealing synergies and trade-offs allows policymakers and other stakeholders to understand the hidden consequences of preferring one intervention or approach to another (Haase et al. 2012).

Consequently, the aim of this study is to apply the SAFA-consistent SMART-Farm Tool to compare the sustainability performance of certified (organic and or fair trade) and non-certified smallholder farms in both Robusta and Arabica coffee production systems in Uganda. Additionally, to use the sustainability performance scores to analyze the synergies and trade-offs between sustainability themes among these farms.

The next section describes the data collection process, the SMART-Farm Tool and data collection, and the empirical methods used for analysing synergies and trade-offs. This is followed by descriptive and empirical results, which we discuss and draw conclusions in the last section, including uniqueness and potential limitations of the SMART approach.

2. DATA AND METHODS

2.1 The SMART-Farm Tool approach to determining sustainability performance

The SMART-Farm Tool approach (Schader et al. 2016) starts with the proper selection and application of a relevant set of indicators, followed by the determination of the indicator impact weights and finally, the degree of goal achievement of each subtheme. An indicator is defined in the SMART-Farm Tool as a variable that compresses information concerning a relatively complex process, trend or state into a more readily understandable form (Harrington et al. 1993). The SMART-Farm Tool comprises a total of 327 indicators, with 1769 linkages between these indicators and the 58 SAFA sub-themes. An applicable indicator set $R_1$ is automatically selected for each farm interview, using a ‘relevance-check’ function of the SMART-Farm Tool. The indicator selection is done at three levels; the geographic region (temperate, tropical), size of the farm (large, medium, smallholder), and the specific farm components (crop, livestock, hired labour, pesticide or fertilizer use). The relevance check function is standardized to improve efficiency during the interview, by reducing on the number of indicators during the interview that would otherwise be rated as ‘not applicable’ and to reduce subjectivity of the interviewer in selecting relevant indicators.

The relevance check therefore ensures that the indicators used meet the following criteria (Lebacq et al. 2013);

(i) Parsimony: selection of minimal, not redundant, but manageable set of indicators;
(ii) Consistency: all indicators necessary for the interpretation are included in the selected set; and
(iii) Sufficiency: the indicators are exhaustive to include all sustainability goals.

The set $R_1$ (equation 1) are indicators which have an impact $I_{M_i} \neq 0$ for a sub-theme $i$ and are relevant for at least the geographic region, size of farm, or number of farm components. Where $r = 1, \ldots, T$ the $T$ different combinations of size of farm, farm components and geographic regions. $N_{tot}$ denotes the total number of indicators in the SMART-Farm Tool.
RI = \{n \in \{1,\ldots,N_{\text{tot}}\} \mid \exists i \in \{1,\ldots, I\} \text{ so that } IM_{ni} \neq 0 \} \quad \exists \tau \in \{1,\ldots, T\} \text{ so that } n \text{ is relevant for } \tau \quad (1)

The indicator set includes both qualitative and quantitative indicators and thus have different units. However all indicator ratings as assigned by the auditor during the interview according to the respective units, are normalized on a scale of 0 to 100% in the tool. 0% represents a state where all applicable farm activities are counteracting the goal achievement, while 100% represents a state where the respective sustainability goal have been fully achieved by implementing all relevant beneficial activities on a farm and avoiding all relevant detrimental activities to the greatest extent possible (Schader et al. 2016). This makes it possible to combine both qualitative and quantitative indicators in the analysis. Together with pre-determined impact weights of relevant indicators for respective sub-themes, already built into the tool rated on a scale from -3 to +3 (Schader et al. 2016), the degree of goal achievement by the farm to specific sub-themes is determined. The impacts thus serve as “weights” for the different indicators in assessing the degree of goal achievement for a sub-theme.

Mathematically, the degree of goal achievement \((DGA_{ix})\) of a farm \(x\) with respect to a sub-theme \(i\) (Equation 2) is defined as the relation between the sum of impacts of all indicators \((n=1 \text{ to } N)\) that are relevant for a sub-theme \(i\) \((IM_{ni})\) multiplied by the actual performance of a farm \(x\) with respect to an indicator \(n\) \((IS_{nx})\) and the sum of the impacts multiplied by the maximal performance possible on these indicators \((IS_{\text{max}n})\).

\[
DGA_{ix} = \frac{\sum_{n=1}^{N} (IM_{ni} \cdot IS_{nx})}{\sum_{n=1}^{N} (IM_{ni} \cdot IS_{\text{max}n})} \quad V \text{ and } x \quad (2)
\]

where \(x\) is the index of farms, \(i\) is the index of sub-themes, \(n\) is the index for the indicators that are relevant for the size of farm, type of farm components and in the geographical context of interest. This implies that for each sub-theme, there is a group of indicators that in combination allow for an assessment of the degree of goal achievement, which is expressed on a scale of 0 to 100%. Thus, farms are rated and compared against the degree of achievement, given the specific activities or processes on the farm. Although the analysis for each farm is based on the relevant indicators, the total number of indicators in the SMART-Farm Tool is considered while drawing conclusions from the analysis. The SMART-Farm Tool can be conceptualized as a multi-criteria analysis (Dodgson et al. 2001) for each subtheme of the SAFA guidelines.

2.2 Study context

The study was carried out in the western part of Uganda (Figure 1). Both Robusta (\textit{Coffea canephora}) and Arabica (\textit{Coffea arabica}) coffee are produced in Uganda, of which 90% comes from smallholder farmers. Arabica coffee is commonly found in the high altitude areas of the eastern, western, and southern regions of the country (UCDA 2012). Comparatively, Robusta coffee is a native Ugandan coffee type grown in almost all parts of Uganda. For both coffee types, a number of varieties are available. Robusta coffee can be produced as clonal coffee, a fast maturing and better yielding type than Arabica coffee (USAID-APEP 2008). Coffee is usually intercropped with bananas, annual crops or trees. These intercropping systems offer many agronomic benefits to smallholder farmers for example increase in organic matter or nutrient recycling, soil conservation, longer productivity life cycle of coffee plants and higher biodiversity values (Moguel et al. 1999; Diaz 2012) and are more profitable than banana or coffee monocropping systems (van Asten et al. 2011). According to Jassogne et al. (2012), highest yields can be obtained in systems without shade or with low shade levels. However, these same systems often represent higher production risks (especially drought, pests and diseases), resulting in intensive use of external inputs. In polyculture and agroforestry systems, high yield quality can be obtained with a low level of external inputs and allowing a better adaptation to climate change, higher carbon stocks, and more ecological services (Jassogne et al. 2012).
Data collection and analysis

Data collection was done between July and September 2015. A two-stage sampling approach was applied; first farmer groups belonging to organic and fair trade (FO), fair trade only (FT) and conventional/non-certified (CN) categories were purposively selected. To ensure comparability, respective FO, FT, and CN groups in the Arabica and Robusta regions are structurally similar, in terms of farm sizes and situated within same locations (altitude). Secondly, random samples of farming households were drawn from farmer lists obtained at each of the FO, FT and CN groups (Table 1).

Table 1: Distribution of surveyed farms

<table>
<thead>
<tr>
<th>Production system</th>
<th>Number of farms</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FO</td>
<td>FT</td>
</tr>
<tr>
<td>Arabica</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Robusta</td>
<td>60</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>122</td>
</tr>
</tbody>
</table>

Table 1: Distribution of surveyed farms

The data collection and analysis process is illustrated in six steps (Figure 2). Step 1 (preparation) involved relevant literature reviews, preparation of the farm questionnaire and training of auditors. The literature review was supplemented with specific key informant interviews from farmer-group leaders, input providers and the local agricultural extension officers, to understand the operating context of the surveyed farms. The collected information was used to create specific references and benchmarks for certain indicators in the farm questionnaire, for example...
average crop yields, prices and seasonality of typical farm enterprises, sources and types of inputs used, as well as applicable social dynamics.

Figure 2. The approach to data collection and analysis

The SMART-Farm Tool indicator set was pre-tested on a number of farms to aid proper interpretation of the indicators for the context (check detailed list of indicators in Annex 2 available online as supplementary data). Based on the pre-test results, some indicators were adapted mainly in terms of scope and interpretation. From a set of 327 indicators, between 200 and 292 indicators were applied in the assessment of each farm based on the ‘relevance-check’ described in section 2.1. Farms with more and diverse forms of livestock, hired labour, and which applied externally-sourced inputs like feeds, fertilizers and pesticides, had the largest number of indicators applied. As part of the preparation, the auditors and respective assistants participated in a five-day training to become familiar with the SMART-Farm Tool indicators and how to administer the questionnaire. The training took place in each of the focus locations, giving the opportunity to generate local input into the discussions. Each training session was proceeded with a practical demonstration of the farm interview by the lead researcher. The training topics included an introduction to the aims research project, principles of sustainability assessment, the SAFA guidelines and the SMART-Farm Tool, the farm questionnaire, and general procedures to be followed before, during and after the interview.

Step 2 involved on-farm data collection using the farm questionnaire, administered in an interview with the farmer directly on the farm. All interviews commenced with the general farm data, followed by a farm tour, and concluded with a question and answer (Q&A) session for farm specific information on the rest of the indicators. In step 3, each of the farm questionnaires were reviewed by the auditors for completeness, ensuring that all indicators were answered correctly. Any identified gaps were communicated to the respective auditors for appropriate editing. In step 4, plausibility checks were made on a few selected indicators which generated diverging responses by a third-person. Any data errors were equally verified with the respective auditors or directly corrected to maintain consistency in ratings with available literature. In step 5, the corrected data files were entered into the SMART-Farm Tool software to compute the degree of goal achievement scores, $DGA_i$, per sub-theme as illustrated in Equation 2. The score for a particular theme was then determined as an average of the respective sub-theme scores belonging to that particular theme.

Finally in step 6, additional statistical analyses were conducted using the respective sustainability scores for the themes obtained in step 5. The analysis of variance (ANOVA) test was used to compare scores between and within certification categories. Additionally, we evaluated the synergies and trade-offs using the non-parametric Spearman correlation tests.
rank-correlation test (Spearman 1904). Positive correlation coefficients ($0 < r_s \leq +1$) represented synergies while negative correlation coefficients ($0 > r_s \geq -1$) represented trade-offs. All statistical analyses were performed using IBM SPSS Statistics version 21 (IBM 2012).

3. RESULTS
3.1 Sustainability performance of farms
The sustainability scores vary significantly between the Arabica and Robusta production systems and within the certification categories (Figure 3). On average, farms have high scores in the environmental (62.0%) and social (55.5%) themes, and low scores in economic (48.3%) and governance (43.4%) themes, irrespective of the certification status (Table 2). Considering specific certification categories, fair trade organic (FO) farms perform better than fair trade (FT) farms which perform better than CN farms in both Arabica and Robusta production systems. Although the score patterns are inconsistent between the Robusta and Arabica production systems, certified Arabica farms generally have better scores than certified Robusta farms in most themes. This can be attributed to the fact that Arabica farmers engage in more collective activities (like labour-sharing, saving schemes) through their groups than Robusta farmers.

Figure 3. Performance of Arabica and Robusta farmers with respect to SAFA themes
The sustainability performance of the specific certification categories according to the respective themes:

**Governance themes:** all farms have high scores in terms of participation, corporate ethics and rule of law themes, with low scores in accountability and holistic management themes, especially non-certified farms in both production systems. Certification according to the fair trade standard particularly emphasizes collective action, democratic governance, higher prices (above set minimum prices), price premium for community investments, and workers welfare. Although these requirements are mainly applicable at group level, they positively impact the performance of certified farms in the governance themes.

**Environmental themes:** though overall the environmental performance is better than other dimensions, the environmental performance of certified farms does not significantly differ from non-certified farms in both Robusta and Arabica systems. This is inconsistent with earlier findings that organic certification places more emphasis on environmental sustainability (Chiputwa et al. 2015). Organic standards require the application of good coffee production practices including coffee tree management (pruning and stumping), use of organic manures, mulching, intercropping, preventive pest and disease management. In complement, organic extension officers are attached to organic certified groups to regularly visit and remind farmers of these requirements, on top of annual internal and external inspections. Despite these efforts, the adoption rates of these environmentally-friendly practices among certified farms are still very low. The low adoption of rates of good agricultural practices coupled with the increasing threat of droughts, aging coffee gardens as well as pest and disease risks (twig borer, leaf rust, and coffee wilt disease) pose severe threats to environmental sustainability mainly within the Robusta system (lowlands) and to a lesser extent the Arabica system (uplands).

**Economic themes:** Across farms, scores in the product quality and information theme are high, and least in the investment theme, with better performance among certified than non-certified farms. Most certified farmers engage in group saving schemes where members contribute weekly amounts to a savings fund. Interested members take loans from this fund at modest interest rates to invest in farm infrastructure, other income generating activities as well as helping them to mitigate financial risks. In addition, certified farmers receive an annual payment (‘second payment’) from the cooperative union depending on the coffee quantity they delivered. This payment is higher for fair trade organic farmers than fair trade only farmers. It is sent back to the farmers either in kind through items like good quality coffee seedlings, tarpaulins and other garden tools. Certified farmers additionally receive a fair trade premium for community investments like in clinics, schools, roads and water sources. These benefits are higher for fair trade organic than fair trade farmers and in the Robusta than Arabica systems respectively.

**Social themes:** Although certified farms have high scores in most social themes, the scores in terms of the equity theme are very low. In the Robusta system, the aspect of discrimination in preference for male workers and the limited involvement of women in most farm decisions are prevalent. On the contrary, although use of workers in the Arabica system is very low, the unique steep terrain and wet processing requirements pose even heavier workload challenges for both women and children. Men are not also actively involved to avert the workload challenges. As a result, farmers commonly form ‘solidarity groups’ of five people dominated by women, for labour assistance on rotational basis, for example during peak harvesting seasons - carrying coffee to the washing stations, coffee pulping and drying at the washing stations.

Further analysis of the performance of the respective certification categories according to specific sub-themes is included in Figure 4.
Figure 4. Comparing social, economic, environmental and governance dimensions for the different farm categories
<table>
<thead>
<tr>
<th>Sustainability Themes</th>
<th>Arabic CN (N=60)</th>
<th>Robusta CN (N=60)</th>
<th>Arabic FO (N=60)</th>
<th>Robusta FO (N=60)</th>
<th>Arabic FT (N=60)</th>
<th>Robusta FT (N=62)</th>
<th>Total (N=362)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>Corporate Ethics</td>
<td>0.324</td>
<td>0.015</td>
<td>0.281</td>
<td>0.054</td>
<td>0.671</td>
<td>0.023</td>
<td>0.670</td>
</tr>
<tr>
<td>Accountability</td>
<td>0.037</td>
<td>0.011</td>
<td>0.065</td>
<td>0.030</td>
<td>0.475</td>
<td>0.061</td>
<td>0.527</td>
</tr>
<tr>
<td>Participation</td>
<td>0.341</td>
<td>0.022</td>
<td>0.534</td>
<td>0.065</td>
<td>0.672</td>
<td>0.050</td>
<td>0.703</td>
</tr>
<tr>
<td>Rule of Law</td>
<td>0.501</td>
<td>0.019</td>
<td>0.472</td>
<td>0.079</td>
<td>0.657</td>
<td>0.061</td>
<td>0.642</td>
</tr>
<tr>
<td>Holistic Management</td>
<td>0.039</td>
<td>0.015</td>
<td>0.022</td>
<td>0.015</td>
<td>0.305</td>
<td>0.020</td>
<td>0.340</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>0.564</td>
<td>0.031</td>
<td>0.578</td>
<td>0.044</td>
<td>0.553</td>
<td>0.023</td>
<td>0.589</td>
</tr>
<tr>
<td>Water</td>
<td>0.703</td>
<td>0.021</td>
<td>0.701</td>
<td>0.074</td>
<td>0.720</td>
<td>0.030</td>
<td>0.708</td>
</tr>
<tr>
<td>Land</td>
<td>0.460</td>
<td>0.008</td>
<td>0.542</td>
<td>0.198</td>
<td>0.474</td>
<td>0.011</td>
<td>0.541</td>
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<tr>
<td>Biodiversity</td>
<td>0.601</td>
<td>0.027</td>
<td>0.593</td>
<td>0.040</td>
<td>0.590</td>
<td>0.033</td>
<td>0.592</td>
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<tr>
<td>Materials &amp; Energy</td>
<td>0.700</td>
<td>0.022</td>
<td>0.666</td>
<td>0.035</td>
<td>0.751</td>
<td>0.021</td>
<td>0.742</td>
</tr>
<tr>
<td>Animal Welfare</td>
<td>0.587</td>
<td>0.076</td>
<td>0.652</td>
<td>0.073</td>
<td>0.552</td>
<td>0.039</td>
<td>0.609</td>
</tr>
<tr>
<td>Investment</td>
<td>0.173</td>
<td>0.040</td>
<td>0.271</td>
<td>0.146</td>
<td>0.432</td>
<td>0.025</td>
<td>0.328</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>0.451</td>
<td>0.042</td>
<td>0.516</td>
<td>0.042</td>
<td>0.561</td>
<td>0.029</td>
<td>0.550</td>
</tr>
<tr>
<td>Product Quality &amp; Information</td>
<td>0.509</td>
<td>0.017</td>
<td>0.507</td>
<td>0.026</td>
<td>0.707</td>
<td>0.041</td>
<td>0.719</td>
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<tr>
<td>Local Economy</td>
<td>0.374</td>
<td>0.061</td>
<td>0.464</td>
<td>0.051</td>
<td>0.508</td>
<td>0.018</td>
<td>0.495</td>
</tr>
<tr>
<td>Decent Livelihood</td>
<td>0.350</td>
<td>0.022</td>
<td>0.346</td>
<td>0.031</td>
<td>0.560</td>
<td>0.024</td>
<td>0.357</td>
</tr>
<tr>
<td>Fair Trading Practices</td>
<td>0.824</td>
<td>0.010</td>
<td>0.460</td>
<td>0.269</td>
<td>0.926</td>
<td>0.016</td>
<td>0.505</td>
</tr>
<tr>
<td>Labour Rights</td>
<td>0.362</td>
<td>0.006</td>
<td>0.310</td>
<td>0.121</td>
<td>0.772</td>
<td>0.084</td>
<td>0.500</td>
</tr>
<tr>
<td>Equity</td>
<td>0.000</td>
<td>0.000</td>
<td>0.141</td>
<td>0.177</td>
<td>0.276</td>
<td>0.117</td>
<td>0.253</td>
</tr>
<tr>
<td>Human Safety &amp; Health</td>
<td>0.840</td>
<td>0.023</td>
<td>0.709</td>
<td>0.048</td>
<td>0.835</td>
<td>0.010</td>
<td>0.756</td>
</tr>
<tr>
<td>Cultural Diversity</td>
<td>0.724</td>
<td>0.027</td>
<td>0.650</td>
<td>0.073</td>
<td>0.764</td>
<td>0.036</td>
<td>0.721</td>
</tr>
</tbody>
</table>

ANOVA test – sustainability scores varied significantly across the certification groups at 5%; FO= fair trade organic; FT = fair trade; CN=Conventional/Non-certified
3.2 Analysis of interactions within sustainability themes

Using the sustainability scores in Table 2, we analyzed the interactions within sustainability themes using Spearman correlation test. Generally, we find major synergies between governance and economic (63.0%) followed by governance and social (38.0%) themes (Table 3). On the contrary, major trade-offs are observed within the environmental dimension and other dimensions. Though inconsistent, certified farms generally exhibit more synergies than non-certified farms. Besides certification, there is a consistent pattern in the distribution of synergies and trade-offs between the production systems, with more synergies within the Arabica than the Robusta system.

Table 3. Spearman correlation values between sustainability themes

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Good Governance</th>
<th>Environmental Integrity</th>
<th>Economic Viability</th>
<th>Social Well-being</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate Goals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accountability</td>
<td>+0.140</td>
<td>+0.630</td>
<td>+0.380</td>
<td></td>
</tr>
<tr>
<td>Participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade of Goods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Economy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Indicators</td>
<td></td>
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</tr>
</tbody>
</table>

4. DISCUSSION AND CONCLUSIONS

Sustainability assessments of agricultural production systems differ in terms of objectives, target audiences, indicators as well as spatial and temporal scales. This study aims at: (i) comparing the sustainability performance of certified and non-certified coffee farms in both Arabica and Robusta production systems in Uganda, using a set of pre-determined sustainability indicators following the SMART-Farm Tool approach, and (ii) using the respective farm scores, to analyse the synergies and trade-offs between sustainability themes among the different farm categories.

Although the sustainability scores of farms are significantly different across certification categories, a consistent pattern (the sustainability profile) is observed. All farms have high scores in the environmental and social dimensions, and low scores in the governance and economic dimensions, irrespective of the certification status.
(Figure 4). This is characteristic of smallholder farming systems where the social structures tend to be strong, and negative environmental impacts are low due to the extensive nature of the production systems. This is also true for most coffee smallholders in Uganda – they are weak economically and in terms of governance dimensions of sustainability (Ssebunya et al. 2016). The consistent sustainability profile implies that farms within the same production system experience similar sustainability opportunities and challenges, irrespective of the certification status. Though not consistent across all themes, the sustainability scores of Arabica farms are significantly different from Robusta farms. This can be attributed to the structural differences between Arabica and Robusta coffee production systems in Uganda. These systems differ in terms of their resource availability, history and opportunities (Jassogne et al. 2012), which influence the way coffee farms are managed and thus the sustainability scores.

Comparing the certified and non-certified farms, we find that the sustainability scores of certified are significantly higher than non-certified farms. Among the certified categories, the scores of fair trade organic (FO) are also significantly higher than fair trade (FT) farms. This is consistent with studies, which have reported positive impacts of certification on smallholder livelihoods; for example certification has been reported to significantly contribute to the improvement of livelihoods and the ability of farmers to cope with challenges, mainly through knowledge transfer, access to capital and capacity building (Altenbuchner et al. 2014) as well as higher farm revenues (Bolwig et al. 2009; Chiputwa et al. 2015).

As presented in Figure 3, no production system performs consistently well in all sustainability themes. The individual farm scores vary across themes, owing to varied opportunities and challenges that the farms are exposed to. Differences in climatic, institutional, cognitive, or political influences can affect the way coffee is produced. At different levels, sustainability goals can be in direct conflict (NAS 2010). Thus the need to further analyse relationships between the sustainability themes across certification categories and production systems.

Generally, the analysis of interactions at theme level also reveals more synergies (less trade-offs) within sustainability dimensions among certified than non-certified farms. Larger synergies are observed with the good governance dimension and other dimensions (especially social wellbeing and economic resilience), which emphasizes the importance of the good governance dimension in influencing the level of performance in the other sustainability dimensions (Schader et al. 2016). This implies that a specific focus on the good governance dimension can improve the sustainability performance of farms through its synergistic interactions with the other dimensions of sustainability. On the contrary, several trade-offs are observed with the environment integrity dimension and other dimensions, emphasizing the fact that specific attention is needed to improve environmental sustainability. While the extent and distribution of the synergies and trade-offs varies among certified and non-certified farms, they are consistent between the production systems. This implies that the production systems have more influence on the sustainability performance than the certification per se. However studies show that trade-offs and synergistic relationships are not necessarily stable and can change over time (Haase et al. 2012), and vary over a wide range of conditions (Walker and Salt 2006). Therefore, sustainability-enhancing interventions need to be prioritized depending on the context and status of the farms, while policy can support the transition process to more sustainable systems.

Possible certification contributions

Results have shown that certification is associated with improved sustainability performance. The question, remains: how does certification contribute to improved sustainability performance of certified farms? Certification was originally perceived as a strategy for strengthening the position of coffee smallholders in the value chain. The direct interactions between producers and buyers in certified systems reduce the transaction costs and market risks (Hoebink et al. 2014). These interactions further enhance knowledge transfer on sustainability-enhancing practices. Both fair trade and organic certification schemes provide incentives for achieving these goals. Fair trade certification guarantees minimum prices paid to farmers at purchase and ensures an additional fair trade premium for capacity building and related community projects (Fair Trade Foundation, 2012). All surveyed certified farms have fair trade
certification and thus benefit from this minimum price requirement, but only if they sell to the associated cooperative which owns all certification documents. Due to the focus on community projects, determined at the cooperative level, the effects of the fair trade premium are very difficult to assess at farm level. Comparatively, organic certification on top of fetching a higher bonus at the end of the selling season, places more emphasis on environmental sustainability (Chiputwa et al. 2015). Thus farms that are both fair trade and organic (FO) certified are expected to perform much better in terms of sustainability scores than farms that are only fair trade (FT) certified. Incidentally, the difference between environmental sustainability scores is only significant at P<0.05. Although FO and FT groups are structurally similar, the FO groups have a well-established farmer extension system. The organic certification system requires regular training and extension support for all certified farmers. As a result, there are specifically attached organic trainers for each of the organic certified groups. Unlike fair trade (FT) farmers, organic fair trade (FO) farmers are regularly reminded of required sustainable practices. This is expected to have contributed to the marginal difference in sustainability scores of organic and non-organic farmers.

It is further clear that working in groups is an important element of both fair trade and organic certification schemes. Farmer groups are key for increasing the scale of production, quality assurance, and to guarantee the reliability of small holders as preferred suppliers in the value chain (Hoebink et al. 2014). Schader et al. (2016) also concluded that the governance is very important with regard to achieving a good level of performance in the other sustainability dimensions. We, therefore, expect that the governance scores which are directly influenced by collective action in a smallholder context, positively impact scores in other dimensions and overall sustainability performance of farms. Looking at interactions between sustainability themes (see Table 3), the good governance dimension exhibits a strong positive influence on other sustainability dimensions. We, therefore, conclude that certification contributes to the achievement of governance goals through its influences on group organization and collective capacities, also referred to as the ‘cooperative effect’ in Jena et al. (2012), which results in positive effects on other dimensions of sustainability.

**Limitations and potential improvements of the SMART-Farm Tool approach**

The SMART-Farm Tool approach as a scientific method has intrinsic limitations and specific requirements to deliver credible and consistent results. First, like any survey-based approach, the audit team need to be adequately prepared and trained. In the SMART-Farm Tool approach, this involves a one-week theoretical and practical on-farm training to ensure proper understanding of the indicators and their application. Currently the SMART indicator set is in English and yet in most cases, assessments are done in local languages. Adequate preparation therefore minimizes the risk that information is lost or misinterpreted during the interview process. The auditors also need good agronomic background or experience to be able to understand the indicator terminology. It is equally necessary that auditors have good understanding of the local context. This is helpful when interpreting indicators that require comparisons with generally accepted local practices and performance benchmarks.

Secondly, with a large set of indicators, the SMART-Farm Tool approach is challenged in terms of efficiency, whereby auditor fatigue can potentially affect the results. Although the ‘relevance-check’ function of the SMART-Farm Tool is designed to address this limitation, the auditor’s contribution in applying the function is equally important. Third, though the SMART-Farm Tool approach is comprehensive, there is an intrinsic trade-off in terms of level of detail in the analysis of some sub-themes. For example ‘Energy Use’ and ‘Greenhouse Gases’ can be studied more quantitatively using life cycle assessment method and ‘profitability’ can also be analyzed through detailed calculation of farm incomes and expenditures. Lastly, with limited documentation and record keeping of farm practices at smallholder level, the approach relies heavily on oral responses in a cross-sectional interview which are sometimes contradictory to available literature. For example most farmers reported no child labour incidences and yet one study shows that the average age at which children begin working in coffee in Uganda is eleven, and that 48 percent of children working in the sector reported physical injuries (Obua 2004). Equally, most farmers reported climate change effects on coffee yields to be less than 20%, while Adhikari et al. (2015) project up...
to 40% decrease in coffee yields due to climate change effects. In other cases, the risk of respondent biases arises out of self-reported impacts of farm activities, for example on workers’ welfare, or relationships with neighbouring farms and other stakeholders. Therefore complementary interviews with workers, neighbouring farms or other key stakeholders and reference to available literature can be helpful to validate farmer responses.

Nevertheless, the SMART-Farm Tool approach provides a rapid way to benchmark farms across farm types and regions at dimension, theme and sub-theme levels (Schader et al. 2016). This contributes to the growing need for rapid sustainability assessment methods that provide results in a cost-efficient manner to support policymaking and decision-making (Ran et al. 2015). The approach is also complementary to other well established tools and methods for measuring resource efficiency quantitatively, e.g. via life cycle assessments. As part of the on-going developments of the tool, a stakeholder-wide validation of the indicator weights has been conducted and the subsequent publication of the findings is underway. In addition, there are on-going efforts to apply the tool in diverse contexts.

Acknowledgements
The authors thank farmers and management of the two cooperatives that willingly participated in this study. The funding of this study was made available by the Mercator Foundation Switzerland through the Research Institute of Organic Agriculture (FiBL), Frick, Switzerland.

REFERENCES


### Annex 1. SAFA dimensions, themes, sub-themes and their respective sustainability objectives (FAO 2014)

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Themes</th>
<th>Sub-themes</th>
<th>Sub-theme Sustainability Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Governance</td>
<td>Corporate Ethics</td>
<td>Mission Statement</td>
<td>The enterprise has made its commitment to all areas of sustainability clear to the public, to all personnel and other stakeholders through publishing a mission statement or other similar declaration (such as a code of conduct or vision statement) that is binding for management and employees or members.</td>
</tr>
<tr>
<td>Good Governance</td>
<td>Corporate Ethics</td>
<td>Due diligence</td>
<td>The enterprise is pro-active in considering its external impacts before making decisions that have long-term impacts for any area of sustainability. This is accomplished through the enterprise following appropriate procedures such as risk assessment and others that ensure that stakeholders are informed, engaged and respected.</td>
</tr>
<tr>
<td>Accountability</td>
<td>Holistic Audits</td>
<td>All areas of sustainability in the SAFA dimensions that pertain to the enterprise are monitored internally in an appropriate manner, and wherever possible are reviewed according to recognized sustainability reporting systems.</td>
<td></td>
</tr>
<tr>
<td>Accountability</td>
<td>Responsibility</td>
<td>Senior management and/or owners of enterprise regularly and explicitly evaluate the enterprise’s performance against its mission or code of conduct</td>
<td></td>
</tr>
<tr>
<td>Transparency</td>
<td>Holistic Audits</td>
<td>All areas of sustainability in the SAFA dimensions that pertain to the enterprise are monitored internally in an appropriate manner, and wherever possible are reviewed according to recognized sustainability reporting systems.</td>
<td></td>
</tr>
<tr>
<td>Transparency</td>
<td>Responsibility</td>
<td>Senior management and/or owners of enterprise regularly and explicitly evaluate the enterprise’s performance against its mission or code of conduct</td>
<td></td>
</tr>
<tr>
<td>Transparency</td>
<td>Transparency</td>
<td>All procedures, policies, decisions or decision-making processes are accessible where appropriate publicly, and made available to stakeholders including personnel and others affected by the enterprise’s activities.</td>
<td></td>
</tr>
<tr>
<td>Participation</td>
<td>Stakeholder Dialogue</td>
<td>The enterprise pro-actively identifies stakeholders, which include all those affected by the activities of the enterprise (including any stakeholders unable to claim their rights), and ensures that all are informed, engaged in critical decision making, and that their input is duly considered.</td>
<td></td>
</tr>
<tr>
<td>Participation</td>
<td>Stakeholder Dialogue</td>
<td>Grievance Procedures</td>
<td>All stakeholders (including as stated above, those who cannot claim their rights, personnel, and any stakeholders in or outside of the enterprise) have access to appropriate grievance procedures, without a risk of negative consequences</td>
</tr>
<tr>
<td>Participation</td>
<td>Stakeholder Dialogue</td>
<td>Conflict Resolution</td>
<td>Conflicts between stakeholder interests and the enterprise’s activities are resolved through collaborative dialogue (i.e. arbitrated, mediated, facilitated, conciliated or negotiated), based on respect, mutual understanding and equal power.</td>
</tr>
<tr>
<td>Rule of Law</td>
<td>Legitimacy</td>
<td>The enterprise is compliant with all applicable laws, regulations and standards voluntarily entered into by the enterprise (unless as part of an explicit campaign of non-violent civil disobedience or protest) and international human rights standards (whether legally obligated or not).</td>
<td></td>
</tr>
<tr>
<td>Rule of Law</td>
<td>Remedy, Restoration and Prevention</td>
<td>In case of any legal infringements or any other identified breach of legal, regulatory, international human rights, or voluntary standard, the enterprise immediately puts in place an effective remedy and adequate actions for restoration and further prevention are taken.</td>
<td></td>
</tr>
<tr>
<td>Civic Responsibility</td>
<td>Legitimacy</td>
<td>Within its sphere of influence, the enterprise supports the improvement of the legal and regulatory framework on all dimensions of sustainability and does not seek to avoid the impact of human rights, or sustainability standards, or regulation through the</td>
<td></td>
</tr>
<tr>
<td>Resource Appropriation</td>
<td>Holistic Management</td>
<td>Full Cost Accounting</td>
<td></td>
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<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>Enterprises do not reduce the existing rights of communities to land, water and resources, and operations are carried after informing affected communities by providing information, independent advice and building capacity to self-organize for the purposes of representation.</td>
<td>A sustainability plan for the enterprise is developed which provides a holistic view of sustainability and considers synergies and trade-offs between dimensions, including each of the environmental, economic, social and governance dimensions.</td>
<td>The business success of the enterprise is measured and reported taking into account direct and indirect impacts on the economy, society and physical environment (e.g. triple bottom line reporting), and the accounting process makes transparent both direct and indirect subsidies received, as well as direct and indirect costs externalized.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Integrity</th>
<th>Atmosphere</th>
<th>Greenhouse Gases</th>
<th>The emission of GHG is contained.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Air Quality</td>
<td>The emission of air pollutants is prevented and ozone depleting substances are eliminated.</td>
</tr>
</tbody>
</table>

| Water | Water Withdrawal | Withdrawal of ground and surface water and/or use does not impair the functioning of natural water cycles and ecosystems and human, plant and animal communities. |
|       | Water Quality    | The release of water pollutants is prevented and water quality is restored. |

| Land | Soil Quality | Soil characteristics provide the best conditions for plant growth and soil health, while chemical and biological soil contamination is prevented. |
|      | Land degradation | No land is lost through soil degradation and desertification and degraded land is rehabilitated. |

| Biodiversity | Ecosystem Diversity | The diversity, functional integrity and connectivity of natural, semi-natural and agri-food ecosystems are conserved and improved. |
|             | Species Diversity  | The diversity of wild species living in natural and semi-natural ecosystems, as well as the diversity of domesticated species living in agricultural, forestry and fisheries ecosystems is conserved and improved. |
|             | Genetic Diversity  | The diversity of populations of wild species, as well as the diversity of varieties, cultivars and breeds of domesticated species, is conserved and improved. |

<p>| Materials and Energy | Material Use | Material consumption is minimized and reuse, recycling and recovery rates are maximized. |
|                     | Energy Use   | Overall energy consumption is minimized and use of sustainable renewable energy is maximized. |
|                     | Waste Reduction | Waste generation is prevented and is disposed of in a way that does not threaten the health of humans and ecosystems and food |</p>
<table>
<thead>
<tr>
<th>Animal Welfare</th>
<th>Animal Health</th>
<th>Animals are kept free from hunger and thirst, injury and disease.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freedom from Stress</td>
<td>Animals are kept under species-appropriate conditions and free from discomfort, pain, injury and disease, fear and distress.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic Resilience</th>
<th>Investment</th>
<th>Internal Investment</th>
<th>In a continuous, foresighted manner, the enterprise invests into enhancing its sustainability performance.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Community Investment</td>
<td>Through its investments, the enterprise contributes to sustainable development of a community.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-Ranging Investment</td>
<td>Investments into production facilities, resources, market infrastructure, shares and acquisitions aim at long-term sustainability rather than maximum short-term profit.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profitability</td>
<td>Through its investments and business activities, the enterprise has the capacity to generate a positive net income.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vulnerability</th>
<th>Stability of Production</th>
<th>Production (quantity and quality) is sufficiently resilient to withstand and be adapted to environmental, social and economic shocks.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stability of Supply</td>
<td>Stable business relationships are maintained with a sufficient number of input suppliers and alternative procurement channels are accessible.</td>
</tr>
<tr>
<td></td>
<td>Stability of Market</td>
<td>Stable business relationships are maintained with a sufficient number of buyers, income structure is diversified and alternative marketing channels are accessible.</td>
</tr>
<tr>
<td></td>
<td>Liquidity</td>
<td>Financial liquidity, access to credits and insurance (formal and informal) against economic, environmental and social risk enable the enterprise to withstand shortfalls in payment.</td>
</tr>
<tr>
<td></td>
<td>Risk Management</td>
<td>Strategies are in place to manage and mitigate the internal and external risks (i.e. price, production, market, credit, workforce, social, environmental) that the enterprise could face to withstand their negative impact.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Quality and Information</th>
<th>Food Safety</th>
<th>Food hazards are systematically controlled and any contamination of food with potentially harmful substances is avoided.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food Quality</td>
<td>The quality of food products meets the highest nutritional standards applicable to the respective type of product.</td>
</tr>
<tr>
<td></td>
<td>Product Information</td>
<td>Products bear complete information that is correct, by no means misleading and accessible for consumers and all members of the food chain.</td>
</tr>
<tr>
<td>Local Economy</td>
<td>Value Creation</td>
<td>Enterprises benefit local economies through employment and through payment of local taxes.</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Social Well-being</td>
<td>Enterprise</td>
<td>Enterprises substantially benefit local economies through procurement from local suppliers.</td>
</tr>
<tr>
<td>Local Procurement</td>
<td>Quality of Life</td>
<td>Enterprises maintain legally-binding transparent contracts with all employees that are accessible and cover the terms of work and employment is compliant with national laws on labour and social security.</td>
</tr>
<tr>
<td>Capacity Development</td>
<td>Fair Access to Means of Production</td>
<td>Enterprises ensure a fair price is established through negotiations with suppliers that allow them to earn and pay their own employees a living wage, and cover their costs of production, as well as maintain a high level of sustainability in their practices.</td>
</tr>
<tr>
<td>Fair Trading Practices</td>
<td>Responsible Buyers</td>
<td>The enterprise ensures that a fair price is established through negotiations with suppliers that allow them to earn and pay their own employees a living wage, and cover their costs of production, as well as maintain a high level of sustainability in their practices.</td>
</tr>
<tr>
<td>Rights of Suppliers</td>
<td>Free of Association</td>
<td>The enterprise accepts no forced, bonded or involuntary labour, neither in its own operations nor those of business partners.</td>
</tr>
<tr>
<td>Labour Rights</td>
<td>Forced Labour</td>
<td>The enterprise accepts no child labour that has a potential to harm the physical or mental health or hinder the education of minors, neither in its own operations nor those of business partners.</td>
</tr>
</tbody>
</table>
| Equity | Non-discrimination | A strict equity and non-discrimination policy is pursued towards all stakeholders; non-discrimination and equal opportunities are explicitly mentioned in enterprise hiring policies; employee or personnel policies (whether written or verbal or code of conduct) and adequate means for implementation and evaluation are in place.

All producers and employees in enterprises of all scales enjoy a livelihood that provides a culturally appropriate and nutritionally adequate diet and allows time for family, rest and culture.

Primary producers have access to the means of production, including equipment, capital and knowledge.

Through training and education all primary producers and personnel have opportunities to acquire the skills and knowledge necessary to undertake current and future tasks required by the enterprise, as well as the resources to provide for further training and education for themselves and members of their families.

Negotiations and contracts (verbal or written) are transparent, based on equal power, terminated only for just cause, and terms are mutually agreed upon.

All persons in the enterprise can freely execute the rights to: negotiate the terms of their employment individually or as a group; form or adhere to an association defending workers' rights; and collectively bargain, without retribution.

A strict equity and non-discrimination policy is pursued towards all stakeholders; non-discrimination and equal opportunities are explicitly mentioned in enterprise hiring policies; employee or personnel policies (whether written or verbal or code of conduct) and adequate means for implementation and evaluation are in place.

Negotiations and contracts (verbal or written) are transparent, based on equal power, terminated only for just cause, and terms are mutually agreed upon.

All persons in the enterprise can freely execute the rights to: negotiate the terms of their employment individually or as a group; form or adhere to an association defending workers' rights; and collectively bargain, without retribution.

Terms of work and employment are compliant with national laws on labour and social security.

Forced Labour

The enterprise accepts no forced, bonded or involuntary labour, neither in its own operations nor those of business partners.

Labour Rights

The enterprise accepts no child labour that has a potential to harm the physical or mental health or hinder the education of minors.

Freedom of Association

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<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Equality</td>
<td>There is no gender disparity concerning hiring, remuneration, access to resources, education and career opportunities.</td>
</tr>
<tr>
<td>Support to Vulnerable People</td>
<td>Vulnerable groups, such as young or elderly employees, women, the disabled, minorities and socially disadvantaged are proactively supported.</td>
</tr>
<tr>
<td>Human Safety and Health</td>
<td><strong>Workplace Safety and Health Provisions</strong> The enterprise ensures that the workplace is safe, has met all appropriate regulations, and caters to the satisfaction of human needs in the provision of sanitary facilities, safe and ergonomic work environment, clean water, healthy food, and clean accommodation (if offered).</td>
</tr>
<tr>
<td>Public Health</td>
<td>The enterprise ensures that operations and business activities do not limit the healthy and safe lifestyles of the local community and contributes to community health resources and services.</td>
</tr>
<tr>
<td>Cultural Diversity</td>
<td><strong>Indigenous Knowledge</strong> Intellectual property rights related to traditional and cultural knowledge are protected and recognized.</td>
</tr>
<tr>
<td>Food Sovereignty</td>
<td>The enterprise contributes to, and benefits from, exercising the right to choice and ownership of their production means, specifically in the preservation and use of traditional, heirloom and locally adapted varieties or breeds.</td>
</tr>
</tbody>
</table>
Group membership and certification effects on incomes of coffee farmers in Uganda

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Review coordinated by Jack Peerlings

Abstract
Discrepancies in certification effects on smallholder incomes have been found in scientific literature. Unobserved farmer-group heterogeneity is a likely reason. For the long-standing Robusta coffee farmer-groups in Uganda, we find no significant effect of certification on net-farm income. But, we find 20 percentage point differences in net-farm income between certified and non-certified farmers explained by membership duration. In contrast, the recently founded certified Arabica coffee farmer-groups have positive net-farm income effects of 151 per cent, partly explained by a higher degree of vertical integration. With or without certification, long-standing group membership is found to have positive income effects.

Keywords: certification, group membership, farm income, coffee production, Uganda

JEL classification: Q13

1. Introduction
Several studies have shown that certification contributes to significant farm income gains through price premiums, reduced production risks and productivity increases (Arnould et al., 2009; Bolwig, Gibson and Jones, 2009; Karki, Jena and Grote, 2016), while a few have found no measurable effect of certification on income (Jena et al., 2012; Akoyi and Maertens, 2018). One key requirement for certification is that farmers need to belong to some form of organisation in order to reduce inspection and certification costs (Chiputwa, Spielman and Qaim, 2015). This requirement means that certification is inevitably interlinked with group membership (Jena et al., 2012; Ssebunya et al., 2016), which has implications for the estimation of

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certification effects. Farmer-groups differ in terms of size and duration of membership, governance, production techniques and social capital aspects. Together with the production and marketing systems to which they belong, this will in turn influence member characteristics with or without certification (Jena et al., 2012; Ssebunya et al., 2016). It is further expected that the positive effects of group membership on farm incomes will accrue with membership duration. For instance, Menon (2006) finds that Bangladeshi women with longer membership duration in microfinance programmes are better equipped to minimise consumption fluctuations. With respect to marketing performance, Barham and Chitemi (2009) identify higher trust among members, more altruistic behaviour and generally more social capital in long-standing groups. It therefore seems likely that trust, altruistic behaviour and social capital increase with membership duration, even in this case of agricultural production.

In this article, we analyse how certification effects on farm incomes are influenced by the duration of group membership of coffee farmers in Uganda. We use survey data from coffee farmers organised under two cooperatives, which represent two coffee production systems (‘Arabica’ and ‘Robusta’), each with three certification categories (‘fairtrade’, ‘organic and fairtrade’ and ‘no certification’). Most articles focus on certification within one production system. We also illustrate how the employed production techniques make a difference in vertical integration. Although we cannot disentangle the specific location, production system and individual group aspects, we explicitly test how the duration of group membership contributes to certification effects on farm incomes. However, group membership duration is just one among many group specific aspects influencing farm income. Given that we have only cross-sectional data from six farmer-group categories, we may not control for group specific effects in a way that allows statistical inference.

We use sequential g-estimation to test the effect of group membership duration as a mediator for certification, a method originally described for political science (Acharya, Blackwell and Sen, 2016), but also used in agricultural economic research (Bellemare, Lee and Novak, 2017). The method is intended for cases where the treatment (certification) affects the outcome (farm incomes) through a mediator (group membership duration). The conventional way of simply controlling with an additional independent variable is potentially biased, though in our case this bias is rather small.

The next section starts with the sampling design, data collection and the related description of the coffee handling processes. This is followed by the presentation of descriptive statistics, the empirical investigation and results, followed by the discussions and conclusions.

2. Sampling design, data collection and coffee handling processes

2.1. Sampling design and data collection

A two-stage sampling approach was applied. First, respective farmer-groups belonging to ‘fairtrade only’ (FT), ‘organic and fairtrade’ (FO) and
no-certification’ (CN) certification categories were purposively selected from two cooperatives (Table 1). The two coffee cooperatives are operating in Sheema (production system ‘Robusta’) and Kasese (production system ‘Arabica’) districts in Western Uganda. The Robusta cooperative is owned by about 14,000 farmers, located at altitudes between 1,600 and 2,000 metres above sea level, while the Arabica cooperative is owned by about 5,500 farmers located in the Rwenzori Mountain ranges, at altitudes up to 2,200 metres above sea level. Both cooperatives have more FO, followed by FT, than CN farmer-groups – farmers graduate from CN to FT and later to FO. Farmer-groups were selected from neighbouring villages to limit variability due to physical location (terrain and road access), electricity and water access. Second, random samples of 60 farmers were then drawn from farmer lists obtained from the respective farmer-groups. The final sample comprised 362 farmers; 120 FO, 122 FT and 120 CN (Table 1). The three (FO, FT and CN) farmer-group categories were drawn from the same cooperatives to avoid heterogeneity that may be correlated with cooperative membership (and not certification).

Data were collected using structured questionnaires, administered by a team of enumerators who were trained prior and monitored through the data collection exercise. The structured questionnaires gathered information on farm and farmer characteristics – farm areas, crops, inputs, coffee specific areas, yields, prices, livestock types, sales and off-farm income. Field data collection was carried out between June and September 2015, considering the reference period (July 2014 to June 2015).

Table 2 shows the characteristics of the selected farmer-groups. The size of groups varies from 90 to 350 members depending on the age and certification status – the older FO groups have more members. Generally, Robusta groups are older than Arabica groups as they were mostly founded during the pre-independence colonial times as part of a government drive to boost coffee production. Despite their early formation, they remained inactive with few members until they joined the respective cooperative. The recently founded Arabica groups have received assistance from non-governmental organisations, originally targeting women in support of collective marketing of coffee. As a result, the groups are dominated by women, representing more than 65 per cent of total membership. In both systems, group-certification requires

<table>
<thead>
<tr>
<th>Cooperative/production system</th>
<th>District</th>
<th>Number of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FO</td>
<td>FT</td>
</tr>
<tr>
<td>Robusta</td>
<td>Sheema</td>
<td>60</td>
</tr>
<tr>
<td>Arabica</td>
<td>Kasese</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>120</td>
</tr>
</tbody>
</table>
### Table 2. Characteristics of sampled farmer-groups

<table>
<thead>
<tr>
<th>Production system/cooperative</th>
<th>Certification</th>
<th>Year of formation</th>
<th>Group size (#members)</th>
<th>Female membership (%)</th>
<th>Organic since (year)</th>
<th>Fair-trade since (year)</th>
<th>Total coffee sales in 2014/15 (kg)</th>
<th>Average coffee prices in 2014/15 (Ushs/kg)</th>
<th>Total premium earned in 2014/15 (Ushs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robusta</td>
<td>FO</td>
<td>1946</td>
<td>287</td>
<td>19.5</td>
<td>2010</td>
<td>2009</td>
<td>74,029</td>
<td>2,700a</td>
<td>26,718,519</td>
</tr>
<tr>
<td></td>
<td>FT</td>
<td>1948</td>
<td>357</td>
<td>31.1</td>
<td>–</td>
<td>2002</td>
<td>68,906</td>
<td>2,700b</td>
<td>25,848,682</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>1962</td>
<td>91</td>
<td>26.4</td>
<td>–</td>
<td>–</td>
<td>9,641</td>
<td>2,500b</td>
<td>–</td>
</tr>
<tr>
<td>Arabica</td>
<td>FO</td>
<td>1999</td>
<td>114</td>
<td>86.8</td>
<td>2010</td>
<td>2010</td>
<td>15,373</td>
<td>1,000b</td>
<td>13,374,000</td>
</tr>
<tr>
<td></td>
<td>FT</td>
<td>2012</td>
<td>200</td>
<td>74.5</td>
<td>–</td>
<td>2014</td>
<td>3,137</td>
<td>1,000b</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>CN</td>
<td>2015</td>
<td>150</td>
<td>68.0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

aDried coffee ("kiboko").
bFresh coffee beans.
that a farmer can only belong to one group at a time, but can leave the group at will, in which case the certification status will be lost. Farmer-groups therefore continuously recruit new members upon payment of a membership fee and willingness to abide by the group rules. On the other hand, farmer-groups have to meet certain requirements to work with the respective cooperatives such as having a leadership structure, a facility to bulk coffee (store), internal governance rules (bye-laws) and a register of members.

The cooperatives pay for the certification and receive the certificates covering all associated farmer-groups operating under their respective schemes. Farmer-groups can only sell the coffee as certified through the cooperatives which they are associated to – FO and FT farmers are paid the same mutually agreed farmgate price within a particular buying season.

2.2. Coffee handling processes

Figure 1 shows the coffee handling processes within the Arabica and Robusta production systems, and certification categories. All certified groups receive annual premiums (from their respective coffee buyers) and dividends (from the respective cooperatives) depending on how much coffee the group has sold to the cooperative. These payments are higher for FO than FT coffee; the FO receive a premium for fairtrade and another for organic certification. At the farmer-group level, farmer representatives decide how the money is invested in joint projects (like office buildings, land, coffee seedlings, tarpaulins and garden tools) or distributed in form of cash to the members. The certification premium, particularly from fairtrade, is used for community investments (like hospitals, schools, roads and water sources) that benefit the community at large, not just farmer-group members.

Farmgate prices received by the individual farmers depend on the level of vertical integration in the coffee value chain. Robusta farmer-groups buy dried cherries (‘kiboko’) from farmers and sell milled Robusta beans to the cooperative at nearly double the farmgate prices. Arabica farmer-groups buy fresh ‘Arabica Cherries’ and sell wet processed ‘Arabica parchment’ at nearly five times the farmgate price. ‘Wet processing’ is a peculiarity of certified farmers (FO and FT) in the Arabica system. Wet processing yields higher quality coffee, known as WUGAR (washed Uganda Arabica). On the other hand, non-certified farmers employ the dry (natural) processing method of coffee processing, which results in the low-grade coffee known as DRUGAR (dried Uganda Arabica). There is a premium of at least 13.5 per cent on WUGAR as compared to DRUGAR coffee Free on Board (FOB) prices in Uganda (ITC, 2016).

Comparing prices between certified (FO and FT) and non-certified (CN) Robusta parchment coffee from 2013 to 2015, we find differences between 4 and 9 per cent. Comparing prices between certified and non-certified Arabica coffee is not informative because of differences in the production techniques – dry processed for CN and wet processed for FT and FO coffee. As indicated in
In Figure 2, there is little variation in the respective coffee prices for certified coffee during the six seasons (3 years) in the period 2013–2015. It was equally established that the price difference between certified and non-certified coffee is very small during the observed time period: although FT establishes a price floor for certified coffee, the price floor is not effective if conventional prices are higher or equal to certified coffee prices (Kilian et al., 2004). While other studies have reported significant price premiums due to better quality (Kilian et al., 2004), coffee quality in our study was largely compromised by the many alternative markets for different qualities of both certified and non-certified coffee. Up to 50 per cent of the harvested coffee is sold to middlemen, mainly in the Robusta system.

### 3. Descriptive statistics

Table 3 shows the characteristics of the farms and farmers by production system and certification category. Generally, Robusta and Arabica production systems are significantly different in many farm and farmer characteristics. Robusta farmers are better in important production-related characteristics than Arabica farmers (e.g. education, use of permanent workers, livestock ownership). These differences can be attributed to location, infrastructural and socio-economic differences between the two coffee producing regions. Particularly, Robusta farmers are easily accessible with diverse farm and
non-farm income-earning opportunities. On the contrary, Arabica farmers are remotely situated with limited access to alternative markets for farm products as well as other income-earning opportunities. As a result, Arabica farmers heavily rely on coffee.

Comparing CN and FT Robusta farmers, we find significant differences in terms of years of education, household size, duration of group membership, engagement in leadership positions, total land owned and use of external inputs. On average, FT farmers have more years of formal education, more household members, more land, hold more leadership positions and are less likely to use external inputs than CN farmers. Compared to FO farmers, FT farmers have less coffee growing experience and duration of group membership. Within the Arabica system, FT farmers have similar differences as in the Robusta system, in addition to better access to electricity, livestock ownership, tree ownership, savings and access to off-farm income than CN farmers. Similarly, the same differences exist between FO and FT farmers, in addition to less access to loans and lower representation of women than FO farmers.

Table 4 provides information on coffee production, production costs and incomes by production system and certification category. All income variables (coffee income per ha, gross income per ha and net-farm income per ha) are not significantly different between FT and CN farmers, and between FT and FO farmers, respectively, in the Robusta system. The only difference between CN, FT and FO Robusta farmers is the amount of dividends. On the contrary, income differences for the respective categories are observed in the Arabica system. FT farmers have 43.9 per cent higher coffee acreages and thus earn 94.4 per cent higher coffee incomes per ha than CN farmers. Equally, FT farmers earn dividends, and have 45 per cent higher gross income per ha and 77.7 per cent higher net-farm income per ha than CN farmers. Comparatively, FO farmers also earn 1,138.6 per cent more
Table 3. Characteristics of surveyed farmers by production system and certification category. Mean values with standard deviations in parentheses

<table>
<thead>
<tr>
<th>Variable,</th>
<th>Robusta</th>
<th>Arabica</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CN (N = 60)</td>
<td>FT (N = 62)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of the household head (years), X</td>
<td>53.38 (13.93)</td>
<td>51.37 (12.68)</td>
</tr>
<tr>
<td>Male household head (dummy), X</td>
<td>0.72 (0.45)</td>
<td>0.65 (0.48)</td>
</tr>
<tr>
<td>Education of the household head (years), X</td>
<td>4.33 (3.90)</td>
<td>7.35*** (4.69)</td>
</tr>
<tr>
<td>Coffee production experience (years), X</td>
<td>21.15 (15.17)</td>
<td>18.74 (12.38)</td>
</tr>
<tr>
<td>Household size (persons), X</td>
<td>5.57 (2.06)</td>
<td>7.11*** (2.97)</td>
</tr>
<tr>
<td>Social capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group membership (years), M</td>
<td>2.32 (0.81)</td>
<td>5.73*** (7.44)</td>
</tr>
<tr>
<td>Permanent workers (persons), Z</td>
<td>0.47 (0.77)</td>
<td>0.39 (0.49)</td>
</tr>
<tr>
<td>Community/group leadership (dummy), X</td>
<td>0.28 (0.45)</td>
<td>0.68*** (0.47)</td>
</tr>
<tr>
<td>Physical capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total farm land (ha), Z</td>
<td>1.92 (1.44)</td>
<td>2.49* (2.19)</td>
</tr>
<tr>
<td>Phone ownership (dummy), Z</td>
<td>0.92 (1.39)</td>
<td>0.82 (0.39)</td>
</tr>
<tr>
<td>Electricity access (dummy), Z</td>
<td>0.20 (0.40)</td>
<td>0.23 (0.42)</td>
</tr>
<tr>
<td>Livestock ownership (TLU), Z</td>
<td>1.62 (2.22)</td>
<td>1.57 (2.17)</td>
</tr>
<tr>
<td>Timber trees ownership (ha), Z</td>
<td>0.27 (0.73)</td>
<td>0.35 (0.47)</td>
</tr>
<tr>
<td>Financial capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm savings (1,000 Ushs), Z</td>
<td>371.33 (1225.45)</td>
<td>635.51 (1096.13)</td>
</tr>
<tr>
<td>Farm loans (1,000 Ushs), Z</td>
<td>171.50 (383.47)</td>
<td>90.65 (310.13)</td>
</tr>
<tr>
<td>Off-farm income access (dummy), Z</td>
<td>0.21 (0.25)</td>
<td>0.14 (0.26)</td>
</tr>
<tr>
<td>Natural capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External inputs access (dummy), Z</td>
<td>0.28 (0.45)</td>
<td>0.03*** (0.18)</td>
</tr>
</tbody>
</table>

Note: Stars next to mean FT values indicate a significant difference to mean CN values. Stars next to mean FO values indicate significant difference to mean FT values: 1% (***) , 5% (**) and 10% (*) levels. TLU (tropical livestock units) are livestock numbers converted to one common unit, where cattle = 0.7, sheep/goats = 0.1, pigs = 0.2, chicken = 0.01.
Table 4. Farm production costs and incomes by production system and certification category. Mean values with standard deviations in parentheses

<table>
<thead>
<tr>
<th>Variable</th>
<th>Robusta</th>
<th>Arabica</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CN (N = 60)</td>
<td>FT (N = 62)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN (N = 60)</td>
</tr>
<tr>
<td><strong>Coffee area (ha)</strong>, Z</td>
<td>0.60 (0.45)</td>
<td>0.71 (0.41)</td>
</tr>
<tr>
<td>Share of coffee area (%)</td>
<td>0.33 (0.17)</td>
<td>0.34 (0.14)</td>
</tr>
<tr>
<td><strong>Farm income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee income (1,000 Ushs/ha), Y</td>
<td>3,881.43 (3,810.08)</td>
<td>3,412.06 (3,042.73)</td>
</tr>
<tr>
<td>Share of coffee income (%)</td>
<td>0.48 (0.28)</td>
<td>0.53 (0.29)</td>
</tr>
<tr>
<td>Other crops income (1,000 Ushs/ha)</td>
<td>1,151.85 (1,288.43)</td>
<td>1,016.15 (1,320.15)</td>
</tr>
<tr>
<td>Dividend (1,000 Ushs/ha)</td>
<td>621.95 (973.78)</td>
<td>599.64 (1,616.17)</td>
</tr>
<tr>
<td>Livestock income (1,000 Ushs/TLU)</td>
<td>349.19 (1,017.24)</td>
<td>256.70 (522.88)</td>
</tr>
<tr>
<td>Gross income (1,000 Ushs/ha)</td>
<td>2,545.59 (1,963.54)</td>
<td>2,474.70 (1,990.72)</td>
</tr>
<tr>
<td><strong>Farm costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour (1,000 Ushs/ha)</td>
<td>194.83 (358.87)</td>
<td>176.65 (380.85)</td>
</tr>
<tr>
<td>Livestock inputs (1,000 Ushs/TLU)</td>
<td>85.30 (241.98)</td>
<td>82.83 (110.58)</td>
</tr>
<tr>
<td>Crop inputs (1,000 Ushs/ha)</td>
<td>69.93 (186.33)</td>
<td>35.74 (121.59)</td>
</tr>
<tr>
<td>Total direct costs (1,000 Ushs/ha)</td>
<td>324.91 (432.64)</td>
<td>272.40 (434.97)</td>
</tr>
<tr>
<td><strong>Net-farm income and savings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net-farm income (1,000 Ushs/ha), Y</td>
<td>1,607.72 (1,257.65)</td>
<td>1,602.66 (1,282.74)</td>
</tr>
<tr>
<td>Savings (1,000 Ushs/ha)</td>
<td>207.00 (539.00)</td>
<td>325.60 (496.56)</td>
</tr>
<tr>
<td>Loans (1,000 Ushs/ha)</td>
<td>101.16 (233.17)</td>
<td>50.04 (191.25)</td>
</tr>
</tbody>
</table>

Note: Stars next to mean FT values indicate a significant difference to mean CN values. Stars next to mean FO values indicate significant difference to mean FT values. 1% (***), 5% (**), and 10% (*) levels.
dividends, 50.4 per cent more net-farm income per ha, have 149.7 per cent more savings and on average 522.5 per cent more loans than FT farmers.

4. Estimating effects of certification and membership duration on farm incomes

Estimating the effect of certification on farm income is econometrically challenging if farmers who join certified groups are different from those that join non-certified groups and their difference is not observable. This will induce unobserved heterogeneity due to selection bias. Such endogeneity problems have been addressed in programme evaluation by using randomised experiments, estimation under the exogeneity assumption (regression methods, propensity score matching and other matching methods) and selection on unobservables (instrument variables, regression discontinuity design and difference in difference methods), see Imbens and Wooldridge (2009) for an overview.

Applying selection on unobservables requires instrument variables, arbitrary discontinuities in the treatment or multi-period observations. Our data do not have these features. Propensity score matching and other matching methods require pretreatment observations to test or control for this unobserved heterogeneity (Imbens and Wooldridge, 2009; Lampach and Morawetz, 2016). There are no pretreatment observations in our data. We thus apply a regression based on the assumption of exogeneity of certification. Our assumption requires that, conditional on the observed variables, there are no unobserved variables that are associated both with being certified and the income of the farm (Imbens and Wooldridge, 2009).

We have three reasons to believe that there is no selection bias. First, all farmers in the sample are group members. The difference between farmers lies just in some groups being already certified and some groups being not (yet) certified. Second, Robusta farmer-groups were founded decades before certification schemes were introduced. This allows us to test if the farmers who joined before the first certification scheme was introduced are significantly different in income compared to those who joined when the groups were certified (while controlling for all other covariates including duration of membership). We find no evidence for a difference. Third, we analyse the sensitivity of the effects of certification with respect to the exclusion of intermediate confounders (i.e. independent variables we consider as potentially changing due to group membership) before estimating the average treatment effect (ATE).

Next to selection bias on farmer level, another issue of identification is unobserved heterogeneity of the farmer-groups. We know that the production system, the cooperative, the farmer-group and production techniques will influence income (Jena et al., 2012; Ssebunya et al., 2016). In our data, 180 farms belong to one cooperative in Sheema which cultivates Robusta coffee with dry processing. The other 182 farms belong to another cooperative in Kasese that cultivates Arabica, with both wet and dry processings. In each of
the cooperatives, we have farms that belong to FO, FT and CN certifications, giving a total of six farmer-group categories. Comparing only farms of the same production system (hence also from the same cooperative), two identification issues still remain. First, each of the six farmer-group categories can have different institutional settings that influence income. Second, for Arabica, the 120 certified farms use wet processing, while the 60 CN farms use dry processing (see Figure 1). With the data at hand, we cannot resolve this identification issue.

Therefore, the main focus of our analysis is not the effect of certification, but to test one of the impact pathways. Figure 3 illustrates the certification impact pathways. Pretreatment confounders (i.e. farm characteristics that do not change with certification) affect the likelihood of certification and, potentially, intermediate confounders (variables which may change with certification, i.e. access to credit). Certification (or non-certification) has an effect on farm income (mainly through dividend cash payment), a potential effect through intermediate confounders (e.g. if membership alters the access to credit) and through membership duration. The effect of membership duration occurs for certified and non-certified farmers alike. It covers all variables related to the social capital generated through membership (e.g. trust among members, more altruistic behaviour and ties to others) not part of intermediate confounders. The dashed lines in Figure 3 represent what is called the ‘Controlled Direct Effect’ (CDE). The CDE is the effect of certification when group membership duration is fixed at zero years. Appendix Tables A6–A12 show there are statistically significant correlations between all groups of variables connected in Figure 3.

The common practice to estimate the average CDE (ACDE) would be to condition the certification effect on membership duration in a regression model. But it has been shown that simply conditioning on an independent variable can seriously bias the estimated treatment effect (Acharya, 2016)
Blackwell and Sen, 2016). One way to estimate the influence of membership duration without bias is the sequential g-estimation (Vansteelandt, 2009; Acharya, Blackwell and Sen, 2016). The method estimates the ‘controlled direct effects’ (i.e. the effect of certification net of membership duration) in the face of a mediator (i.e. group membership duration) and intermediate confounders (other variables influencing farm income possibly influenced by certification).

Let \( Y_i(a) \) be the potential outcome for farm \( i \) if the treatment is set to \( a \), i.e. the farm income if certification is set to ‘certified’. The ATE is the mean difference between two potential outcomes, \( \text{ATE}(a, a') = E[Y_i(a) - Y_i(a')] \) where \( a' \) is an alternative treatment, i.e. ‘not certified’.

We define \( Y_i(a, m) \) as the value of the outcome that unit \( i \) would take for a treatment \( a \) and the mediator \( m \). The CDE and ACDE are the effect of changing the treatment while fixing the value of the mediator at some level \( m \) (Robins, 2003), that is, \( \text{CDE}(a, a', m) = Y_i(a, m) - Y_i(a', m) \), while \( \text{ACDE}(a, a', m) = E[Y_i(a, m) - Y_i(a', m)] \). A non-zero ACDE implies that the effect of the treatment is not exclusively due to the mediator (VanderWeele, 2011). For our case, a non-zero ACDE means that it is not just group membership duration that makes difference in income but certification impacts through other pathways (such as premiums or access to credit) as well.

To set the ACDE in relation, the ATE must be estimated. Our ordinary least square estimated ATE includes group specific effects not necessarily causal to certification as such (see above). Still, it is of relevance to determine the difference between ACDE and ATE in order to understand the influence of group membership on farm income. We use two sets of covariates in the ordinary least square regression; pretreatment confounders \((X)\) and intermediate confounders \((Z)\). They capture a diverse set of farm and farmer characteristics reflecting the different forms of capital required at farm level (Scoones, 1998). Tables 3 and 4 show the pretreatment and intermediate confounders.

The reduced form of our first model is specified as:

\[
E[Y_i|A_i, X_i, Z_i] = \beta_0 + \beta_1 A_i + \beta_2 X_i + \beta_3 Z_i
\]  

where \( Y_i \) is the income per hectare for farm \( i \) taken as a logarithm. We use two different types of income: (i) net-farm income per ha, calculated as income from coffee, other crops, livestock less all variable costs (purchased inputs and labour) divided by the total farm area. Fixed costs are not subtracted from the dependent variable. And, (ii) coffee income per ha, calculated as coffee revenue divided by the total coffee area. Coffee hectares were estimated based on the number of coffee trees in a given plot of land. We use per ha values because income from certification (premium and dividend payments) is trivially larger for those who produce more (Holzapfel and Wollni, 2014). We control for scale effects by adding farm size and coffee area as intermediate confounders. \( A_i \), which is the treatment variable (certification) is coded as a dummy that equals one if farm \( i \) is certified and zero otherwise.
Bold written $X$ and $Z$ are matrices and the corresponding bold written $\beta_i$ are vectors of coefficients. The coefficient $\beta_1$ measures the average effect of certification (not differentiating between production systems and single- and double certification, and including effects specific to the sampled farmer-groups). The average effect is roughly $100 \times \beta_1$ per cent or exactly $100 \times (\exp(\beta_1) - 1)$ per cent.

We hypothesise that certification effects differ depending on the production systems (Robusta and Arabica), which is interlinked with location, infrastructural and socio-economic differences between the two coffee producing regions: the Arabica and Robusta production systems are different in many aspects (see Tables 3 and 4; Ssebunya et al., 2016). We extend the model specification to address this heterogeneity. For notational simplicity, we disregard that $\beta_i$ in equation (1) is not identical to $\beta_i$ in equations (2) and (3).

$$E[Y|A_1, X_i, Z_i] = \beta_0 + \beta_1 A_{1i}^{\text{rob}} + \beta_2 A_{1i}^{\text{ara}} + \beta_3 A_{i}^{\text{Nara}} + \beta_6 X_i + \beta_7 Z_i,$$

where $A_{1i}^{\text{rob}}$ is a dummy that is equal to a value of one if a certified farm $i$ produces Robusta coffee and zero otherwise; $A_{1i}^{\text{ara}}$ is a dummy that is equal to a value of one if a certified farm $i$ produces Arabica coffee and zero otherwise and $A_{i}^{\text{Nara}}$ is a dummy that is equal to a value of one if a non-certified farm $i$ produces Arabica coffee. We take CN farmers producing Robusta coffee $A_{i}^{\text{Nrob}}$ as the base category. If we hypothesise that certification affects farm incomes positively, the coefficient $\beta_1$ and the difference $\beta_2 - \beta_3$ are positive. The exact difference is $\exp(\beta_2) - \exp(\beta_3)$. This measures the effect of certification specifically for each production systems while not differentiating between double (FO) and single (FT) certification. It will also include effects specific to the sampled farmer-groups, and hence a generalisation is not possible.

In addition to certification effects we also estimated the effects of double certifications (fairtrade and organic). We hypothesise that certification effects on farm incomes vary according to the type of certification(s). To test this hypothesis, we use the following model specification:

$$E[Y|A_1, X_i, Z_i] = \beta_0 + \beta_1 A_{1i}^{\text{rob}} + \beta_2 A_{2i}^{\text{rob}} + \beta_3 A_{1i}^{\text{ara}} + \beta_4 A_{2i}^{\text{ara}} + \beta_5 A_{i}^{\text{Nara}} + \beta_6 X_i + \beta_7 Z_i,$$

where $A_{1i}^{\text{rob}}$ is a dummy that equals one if a Robusta producing farmer $i$ is FT and $A_{2i}^{\text{rob}}$ is a dummy that equals one when a Robusta producing farmer $i$ is FO. Similarly, $A_{1i}^{\text{ara}}$ is a dummy that equals one if the Arabica producing farmer $i$ is FT and $A_{2i}^{\text{ara}}$ is a dummy that equals one when the Arabica producing farmer $i$ is FO. $A_{i}^{\text{Nara}}$ is a dummy that is equal to a value of one if a CN farm $i$ produces Arabica coffee. We take CN farmers producing Robusta coffee $A_{i}^{\text{Nrob}}$ as the reference category.

The coefficient $\beta_1$ measures the difference between FT Robusta and CN Robusta. The coefficient $\beta_2$ measures the difference between FO Robusta and CN Robusta. The difference between FO and FT is thus $\beta_2 - \beta_1$. The difference between FT Arabica and CN Arabica is $\beta_3 - \beta_5$ and the difference
between FO Arabica and CN Arabica is $\beta_4 - \beta_5$. The difference between FO Arabica and FT Arabica is $\beta_4 - \beta_3$. As part of the sensitivity analysis we estimate equations (1)–(3) additionally without the intermediate confounders $Z$ to evaluate the effects on the coefficients of the treatment variables. As for all other cases, group specific effects cannot be controlled for. The results are thus true for the sample groups, but not generalisable.

As shown in Figure 3, the effect of certification on income may partly work through group membership duration. Testing this hypothesis is first done by adding ‘membership duration’ as an additional independent variable. It is known that this method may lead to biased estimates (Acharya, Blackwell and Sen, 2016). We therefore also apply sequential g-estimation in two steps.

**Step 1:** We regress the outcome $Y$ on the mediator $M$ (‘membership duration’), treatment $A$ (certification) and covariates (pretreatment $X$ and intermediate $Z$) to get an estimate of the demediation function. Thus, estimating the demediation function involves estimation of equations (1)–(3) with the mediator $M$ (‘membership duration’) as additional independent variable.

**Step 2:** We use the demediation function to demediate the outcome and run a regression of this demediated outcome $\tilde{Y}$ on the treatment and the pretreatment covariates. The marginal effect of the treatment in the second stage regression is the estimate of the ACDE (Acharya, Blackwell and Sen, 2016).

In our case, the demediated outcome is

$$\tilde{Y}_i = Y_i - \gamma M_i$$

where $\gamma$ is the estimated coefficient of $M$ in the first step. $\tilde{Y}_i$ is the outcome net of variation due to the mediator.

To estimate the ACDE, Models 1–3 are specified in the second stage (again we note all coefficients with $\beta$ as the context makes it clear that the ATE is not equal the ACDE);

$$E[\tilde{Y}|A_i, X_i] = \beta_0 + \beta_1 A_i + \beta_6 X_i$$

$$E[\tilde{Y}|A_i, X_i] = \beta_0 + \beta_1 A_i^{rob} + \beta_2 A_i^{ara} + \beta_3 A_i^{Nara} + \beta_6 X_i$$

$$E[\tilde{Y}|A_i, X_i] = \beta_0 + \beta_1 A_i^{rob} + \beta_2 A_i^{ara} + \beta_3 A_i^{Nara} + \beta_6 X_i$$

The coefficients of $A$ in equations (5)–(7) are the ACDEs. The standard errors are derived analytically as specified in Acharya, Blackwell and Sen (2016) using the software provided in the R-package ‘DirectEffects’ version 0.1 (Acharya, Blackwell and Sen, 2016). All analyses are done with the statistical software R (R Core Team, 2016) and data and code are available from the journal’s webpage.
The estimated ACDE effects are subjected to two specific assumptions that underlie the sequential g-estimation method (Acharya, Blackwell and Sen, 2016);

- Sequential unconfoundedness.

\[
\{ Y_i(a, m), M_i(a) \} \perp A_i|X_i = x, \\
Y_i(a, m) \perp M_i|A_i = a, X_i = x, Z_i = z, 
\]

for all possible treatment values \( a \in A \), mediator values \( m \in M \), and covariates \( x \in X \) and \( z \in Z \). In addition, we assume for all the above values:

\[
P(A_i = a|X_i = x) > 0, \\
P(M_i = m|A_i = a, X_i = x, Z_i = z) > 0.
\]

These assumptions refer to two separate no-omitted-variable assumptions. First, there are no omitted variables for the effect of the treatment on the outcome, conditional on the pretreatment confounders. We discussed this assumption in the previous section in the context of the ATE. Second, there are no omitted variables for the effect of the mediator on the outcome, conditional on treatment and confounders. We conduct a sensitivity analysis to test the implication of violating this assumption: equation (9) implies that the correlation of the error term from equation (1) and the error term \( M_i - E[M_i|A_i, X_i, Z_i] \) equals zero. This correlation is called \( \rho \) in Acharya, Blackwell and Sen (2016) and deviates from zero if there are unmeasured covariates that affect both the mediator and the outcome after controlling for \( A, X \) and \( Z \).

- No intermediate interactions.

\[
E[Y(a, m) - Y(a, m')|X_i = x, A_i = a, Z_i = z] \\
= E[Y(a, m) - Y(a, m')|X_i = x, A_i = a] \\
\text{for all values } a \in A, \ m, m' \in M, \ x \in X \text{ and } z \in Z.
\]

Even if this assumption is not fulfilled, the estimated effects will be weighted averages of ACDEs within levels of the intermediate confounders. Thus, this assumption is similar to omitting an interaction term from a regression model (Acharya, Blackwell and Sen, 2016).

5. Results

One key assumption is that farmers who joined certified groups are not different from those who joined non-certified groups once we control for observable characteristics. Hence, we use a dummy for pre-2002 membership as evidence against this selection bias – Robusta groups were founded long before the first certifications took place in the year 2002. We find that there is no significant
difference in income between those certified farmers who joined pre-2002 and those who joined later. We control for other potential confounders (including the membership duration) and we use the subsample of certified Robusta farmers only (see Appendix Table A1 in supplementary data at ERAE online).

Tables 3 and 4 list certain characteristics of which certified and uncertified farmers differ. We use pretreatment and intermediate confounders to control for this difference when estimating equations (1)–(3). Using intermediate confounders leads to a simultaneity bias if intermediate variables are influenced by certification. However, dropping these variables may lead to an omitted variable bias. Hence, we estimated the models with and without intermediate confounders to evaluate the effect on the treatment coefficients. For equation (1), the difference of the coefficient for certification, $\beta_1$, is 3.38 percentage points (net-farm income) and 7.27 percentage points (coffee income). For equation (2), the difference in the coefficients is between 0.07 (net-farm income) and 8.16 (coffee income) percentage points. For equation (3), the differences are between 0.39 and 15.01 percentage points. While these differences are not negligible, we consider them as acceptable for the purpose of analysing the role of group membership. Detailed results for all models are shown in Table A2 (Appendix in supplementary data at ERAE online).

The ATEs of certification are estimated with equations (1)–(3) and are shown in the first columns of Table 5 (detailed results in Tables A2–A4 in supplementary data at ERAE online). The top part of the table shows the estimated coefficients with respect to the reference category ‘non-certified’ (first row) and ‘non-certified Robusta’ (other rows). These coefficients are the bases for the lower part, where the estimated surplus in per cent is shown (a negative surplus means a discount). The estimated surplus is calculated as the exponential function of the coefficient. Where the surplus (i.e. the dummy) is relative to a treatment not shown in the top panel (e.g. relative to ‘non-certified Arabica’), additional regressions with alternative reference categories were performed to estimate the coefficients and the standard errors (not shown).

Model 1 shows that certified farmers of the sampled groups have a 71.44 per cent higher net-farm income and a 73.50 per cent higher income from coffee on average than non-certified farmers. This certification effect is an average over Robusta and Arabica production systems. At least in the sampled farmer-groups, Model 2 shows that for Robusta farmers there is no significant effect from certification – neither on net-farm income nor on coffee income. In contrast, certified Arabica farmers have on average a 151.35 per cent higher net-farm income and a 166.35 per cent higher coffee income. Recall that non-certified Arabica producers employ dry processing (see Figure 1), while certified Arabica producers use wet processing. Hence, the surplus of certified farms is a combined effect of certification, processing technique and possible other unobserved institutional group characteristics.

Model 3 confirms that Robusta farmers receive no significant increase in income through certification even for FT and FO certifications. For Arabica, the FT farmers have on average 106.73 per cent higher net-farm income and 117.70 per cent higher coffee income than their non-certified colleagues. FO
Table 5. Estimated ATEs (estimating the joint effect of certification and membership), the ATEs conditional on membership duration and the ACDE (from sequential g-estimation fixing the years of membership to 0) of certification on net-farm income and coffee income per ha.

<table>
<thead>
<tr>
<th></th>
<th>Net-farm income</th>
<th>Coffee income</th>
<th>Net-farm income</th>
<th>Coffee income</th>
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<tr>
<td><strong>Coefficients:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CT, Model 1 $\beta_1^+$</td>
<td>0.54*** (0.12)</td>
<td>0.55*** (0.13)</td>
<td>0.44*** (0.13)</td>
<td>0.45*** (0.14)</td>
<td>0.46*** (0.12)</td>
<td>0.41*** (0.12)</td>
</tr>
<tr>
<td>CT Robusta, Model 2 $\beta_1^{++}$</td>
<td>$-0.21$ (0.17)</td>
<td>$-0.41**$ (0.18)</td>
<td>$-0.28^*$ (0.16)</td>
<td>$-0.47**$ (0.19)</td>
<td>$-0.33**$ (0.13)</td>
<td>$-0.39**$ (0.17)</td>
</tr>
<tr>
<td>CT Arabica, Model 2 $\beta_2^{++}$</td>
<td>0.07 (0.15)</td>
<td>0.03 (0.16)</td>
<td>$-0.07$ (0.16)</td>
<td>$-0.08$ (0.17)</td>
<td>$-0.14$ (0.14)</td>
<td>$-0.11$ (0.15)</td>
</tr>
<tr>
<td>CN Arabica, Model 2 $\beta_3^{++}$</td>
<td>$-1.13^{***}$ (0.20)</td>
<td>$-1.39^{***}$ (0.22)</td>
<td>$-1.12^{***}$ (0.20)</td>
<td>$-1.38^{***}$ (0.21)</td>
<td>$-1.41^{***}$ (0.17)</td>
<td>$-1.38^{***}$ (0.19)</td>
</tr>
<tr>
<td>FT Robusta, Model 3 $\beta_1^{++}$</td>
<td>$-0.41^{***}$ (0.18)</td>
<td>$-0.62^{***}$ (0.20)</td>
<td>$-0.44^{***}$ (0.18)</td>
<td>$-0.64^{***}$ (0.20)</td>
<td>$-0.48^{***}$ (0.15)</td>
<td>$-0.62^{***}$ (0.18)</td>
</tr>
<tr>
<td>FO Robusta, Model 3 $\beta_1^{++}$</td>
<td>0.03 (0.17)</td>
<td>$-0.05$ (0.18)</td>
<td>$-0.03$ (0.18)</td>
<td>$-0.09$ (0.18)</td>
<td>$-0.18$ (0.16)</td>
<td>$-0.06$ (0.16)</td>
</tr>
<tr>
<td>FT Arabica, Model 3 $\beta_1^{++}$</td>
<td>0.02 (0.17)</td>
<td>$-0.17$ (0.18)</td>
<td>$-0.06$ (0.17)</td>
<td>$-0.23$ (0.19)</td>
<td>$-0.13$ (0.14)</td>
<td>$-0.07$ (0.17)</td>
</tr>
<tr>
<td>FO Arabica, Model 3 $\beta_1^{++}$</td>
<td>0.09 (0.15)</td>
<td>0.11 (0.16)</td>
<td>$-0.07$ (0.17)</td>
<td>0.00 (0.18)</td>
<td>$-0.03$ (0.15)</td>
<td>$-0.04$ (0.17)</td>
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<tr>
<td>NC Arabica, Model 3 $\beta_5^{++}$</td>
<td>$-1.14^{***}$ (0.20)</td>
<td>$-1.40^{***}$ (0.22)</td>
<td>$-1.13^{***}$ (0.20)</td>
<td>$-1.39^{***}$ (0.22)</td>
<td>$-1.41^{***}$ (0.17)</td>
<td>$-1.37^{***}$ (0.19)</td>
</tr>
<tr>
<td><strong>Surplus in percent:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT over CN</td>
<td>71.44***</td>
<td>73.50***</td>
<td>57.71***</td>
<td>50.16***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT Robusta over CN Robusta</td>
<td>6.78</td>
<td>3.16</td>
<td>$-13.29$</td>
<td>$-10.07$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT Arabica over CN Arabica</td>
<td>151.36***</td>
<td>166.35***</td>
<td>194.30***</td>
<td>169.25***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT Robusta over CN Robusta</td>
<td>3.32</td>
<td>$-4.41$</td>
<td>$-16.84$</td>
<td>$-6.16$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FO Robusta over CN Robusta</td>
<td>9.44</td>
<td>11.53</td>
<td>$-2.93$</td>
<td>$-3.48$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FO Robusta over FT Robusta</td>
<td>5.93</td>
<td>16.67</td>
<td>16.73</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT Arabica over CN Arabica</td>
<td>106.73***</td>
<td>117.70***</td>
<td>153.78***</td>
<td>113.49***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FO Arabica over CN Arabica</td>
<td>217.76***</td>
<td>241.08***</td>
<td>258.11***</td>
<td>268.12***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FO Arabica over FT Arabica</td>
<td>53.71***</td>
<td>56.68***</td>
<td>41.11***</td>
<td>72.43***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Reference category: * CN and ** CN Robusta.
All standard errors (in brackets) are heteroscedasticity robust. Significance levels: ***<0.01, **<0.05 and *<0.1.
Coffee income expressed as gross coffee income.
farmers even have 217.76 per cent higher net-farm income and 241.08 per cent higher coffee income. Again, these are joint effects of wet processing (as the CN farmers apply dry processing), certification and other unobserved group specific effects. Comparing FT and FO farmers, FO farmers have a 53.71 per cent higher net-farm income and a 65.68 per cent higher coffee income. Given that the model is log-linear, the effect of double (FO) certification (e.g. 217.76) does not equal to the sum of single (FT) certification (e.g. 106.73) and the difference between single (FT) and double (FO) certification (e.g. 53.72).

The middle columns of Table 5 show the ATE conditional on controlling for duration of membership (i.e. the results of Models 1–3 with ‘duration of membership’ as an additional independent variable). It is the conventional and potentially biased way of checking the influence of a mediator (the complete regression results are shown in Table A5, Appendix in supplementary data at ERAE online). The right columns of Table 5 show the average CDE (ACDE) derived through sequential g-estimation. In our case, the coefficients of the ATE conditional on ‘duration of membership’ and the ACDE are very similar, though the levels of some variables differ. For example, in Model 2, the net-farm income of Non-Certified Arabica ($\beta_3$) estimated with the conventional OLS is $-1.12$, while it is $-1.41$ when estimated with sequential g-estimation.

The upper part of the right-hand side columns of the Table 5 shows the coefficient of the ACDE (i.e. the treatment dummies conditional on the membership duration being zero years). Thus, if the coefficient of the ACDE is smaller than the ATE, the ATE effect of certification is partly due to the effect of years of membership duration. In contrast, if the ACDE is bigger than the ATE, being a member for longer time reduces ATE. The coefficients in the upper part of the table are used to calculate the effects in the lower part of the table. The ACDE effects for the Model 1 and all Arabica effects in Models 2 and 3 are positive and significantly different from zero. This suggests that even after controlling for years of membership there is a positive effect of certification (and wet processing). As the ATE is not significant for certification of Robusta farmers, the ACDE effect for Robusta is not significant either.

Table 6 shows the differences between the ATE and the ACDE. All but two differences are statistically significant. For Model 1 and for all Robusta effects in Models 2 and 3, we find that the ATE is bigger than the ACDE. The only exception is the net-farm income comparison between FT and FO Robusta farmers. The ATE being bigger than the ACDE suggests that for Robusta some of the difference between certification and non-certification (i.e. of the ATE) is due to membership duration. That is, not all income effects are due to certification. For Arabica, the ATE is smaller than the ACDE in all but two cases. It is not directly obvious why the ATE should be smaller. One possible reason is that the effect of years of membership is not prevalent in the relatively young Arabica groups (founded 1999, 2012 and 2015) and the effects of membership duration have not yet developed. Alternatively, it might be that the higher income of certified Arabica groups
is predominantly due to the effect of value addition through ‘wet processing’. As ‘wet processing’ is not mediated by ‘membership duration’ no influence would be expected, though this is still speculative.

The sequential g-estimation assumption of no omitted variables for the effect of the mediator on the outcome and confounders (which implies no deviation of $\rho$ from zero) was assessed in a sensitivity analysis to test the implication of $\rho$ deviating from zero. Figures A1–A18 Appendix in supplementary data at ERAE online show how the ACDE is influenced if $\rho$ deviates from the assumption of being zero. If a variation in $\rho$ has a large impact on the estimated ACDE, the assumption in equation (9) is questionable. For both coefficients of Model 1 and all but one coefficient for the Arabica groups, the estimated ACDE are different from zero for all $\rho$ values in the range of $[-0.5, 0.5]$ (see Figures A1–A18, Appendix in supplementary data at ERAE online). For the Robusta groups, the ACDE does not significantly change statistically with $\rho$ values in the range of $[-0.5, 0.5]$. This suggests that deviations from the assumptions of equation (9) do not impact the coefficients estimated for Robusta groups.

6. Discussion and conclusion

For Robusta farmers, we do not find a significant effect of certification on net-farm income and coffee income. Equally, there is no significant difference in income between single (FT) and double-certified (FO) farmers. Owing to the diverse income-opportunities available for both, certified and non-certified farmers in the Robusta system, it is not surprising that there is no significant difference in the incomes. In related studies involving Robusta farmers in Uganda, Latynskiy and Berger (2017) found some added value of certification, while Chiputwa, Spielman and Qaim (2015) found that fairtrade certification increases household living standards by 30 per cent while double certification does not necessarily yield additional income gains. Positive
effects of double certification, however, have been reported in other country contexts (Blackman and Rivera, 2010; Ruben and Zuniga, 2011; van Rijssbergen, et al., 2016).

For the sampled Arabica farmer-groups, we find high and significant income effects of certification. Certified farmers have on average 151.35 per cent higher net-farm income and 166.35 per cent higher coffee income than non-certified Arabica farmers. These findings are consistent with earlier studies on Arabica coffee in eastern Uganda. For example, Bolwig, Gibson and Jones (2009) reported that certification boosts net coffee income by 75 per cent. With respect to differences between certification schemes in the Arabica production system, we find FT Arabica farmers have double the income of their non-certified colleagues. FO Arabica farmers also have about 50 per cent more income than FT farmers. This is contrary to findings by Akoyi and Maertens (2018), though in a different context of the eastern part of Uganda. They reported that FO certification neither increases farm incomes, nor reduces poverty among Arabica farmers. But participation in a triple ‘Utz’ – ‘Rainforest Alliance’ – ‘4C’ certification scheme increases coffee income, land and labour productivity though no significant impact on poverty reduction.

The divergence in findings of certification effects is not unique to the Ugandan context. Some authors have attributed such divergence to differences in methods employed (Hoebink et al., 2014). Different methods have been used in Uganda by different authors, for example, instrumental variable (Akoyi and Maertens, 2018), propensity score matching (Chiplutwa, Spielman and Qaim, 2015) and Heckman selection model (Bolwig, Gibson and Jones, 2009). Additionally, differences in certification schemes and their requirements as well as whether farmers belong to outgrower schemes or cooperative structures may also explain some of the divergences in findings. In addition, we find a systematic research design difficulty: coffee certification takes place typically at group level and each group has institutional specificities. The effects of the production systems, the production techniques and social capital are consequently difficult to identify in a statistical model unless one observes many groups. We analyse institutional specificities of our sample by comparing production systems (Arabica vs. Robusta), production techniques (wet vs. dry processing) and eliciting the effect of membership duration.

The certified Arabica producers apply wet processing, while the non-certified apply dry processing. Wet processing yields higher quality coffee (Bolwig, Gibson and Jones, 2009; Millard, 2006). Since non-certified Arabica groups apply dry processing, our estimate of certification for Arabica is a joint effect of certification and the processing technique. One way to interpret the result is that the effect of certification is not identified (i.e. the estimated coefficient is not causal). But, as wet processing requires a higher integration of the value chain, it might also be argued that the difference in production is inherent to certification, that is, without certification, no wet processing is possible. Given the small price surplus for certified coffee, this technological advantage is likely to be the main driver of higher income of
certified farmers. It is an example of how techniques or the degree of vertical integration, which vary only at the group level, can influence estimated certification effects at farm level.

In comparison to production system and production technique, membership duration varies within farmer-groups. This renders membership duration suitable as an identifiable mediator of certification effects on farm income. When we control for membership duration in the sequential g-estimation, we find that the net-farm income is affected – at least in the long-standing Robusta groups. For Robusta, 20.12 percentage points of the FT certification surplus on net-farm income and 12.37 percentage points of the FO certification surplus on net-farm income are due to duration of membership. Without membership duration effects, the average surplus is negative (though not significant in our model). We thus find an income increasing role of years of membership duration for Robusta farmers. This effect may be attributed to effects of group membership beyond what is explained by measurable characteristics like access to credit, electricity or mobile phones. As such these are effects of organising farmers in groups, attributed to trust, altruistic behaviour or social ties that increase with membership duration independent from certification.

For the recently founded Arabica farmer-groups, we find the ACDE to be bigger than the ATE in most cases. One explanation is that the effect of years of membership duration is not prevalent in the relatively young Arabica groups and membership duration is inappropriate for measuring collective action under such circumstances. Alternatively, the effect of the production technique, which is not mediated by ‘membership duration’ might dominate the joint effect of certification and production technique. Additionally, our sensitivity tests question if the assumptions required for an unbiased ACDE for Arabica groups are met.

Based on the results, it is clear that public or donor programmes targeting certification of smallholder farmers can increase the programmes’ cost-effectiveness if farmers can be supported to remain group members for a long time. For example, in Uganda, farmer-groups are already targeted as an important means of increasing adoption of agricultural technologies to enhance agricultural productivity, commercialisation and linking farmers to markets (MAAIF, 2010). Such initiatives can start by exploring ways to secure long-term group memberships. However, beyond only looking at membership duration as channels, direct investment in production techniques, group organisation and capacity building to improve production methods cannot be over-emphasised (as our results of positive significant coefficients of electricity access, savings or off-farm income confirm, see Table A5, Appendix in supplementary data at ERAE online). However, it is important to note that our findings refer to the Ugandan context.

In addition, our analysis demonstrates an underexplored approach to understand certification impact pathways. A deeper understanding of impact differences and factors that contribute to these differences is relevant to all stakeholders (Chiputwa, Spielman and Qaim, 2015). Like many impact studies, this article relies on cross-sectional data and the use of non-certified
entities’ outcomes as the counterfactual outcome. The characteristics of farmer-groups (certified and non-certified) are in many impact studies confounding variables. Sequential g-estimation presents an opportunity for deeper understanding of impact pathways of treatment effects if there is sufficient variation of the mediator within the farmer-groups. The same approach can be used to understand other potential pathways like prices, premiums or investments if these variables vary within groups. Eventually, proper understanding of the different impact pathways will lead to a better understanding of the ‘whole’ certification effect.

Supplementary data
Supplementary data are available at European Review of Agricultural Economics online.

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References


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2) Academic qualifications

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<tr>
<th>Degrees obtained</th>
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<tr>
<td>Doctor of Social and Economic Sciences (Dr.rer. soc.oec)</td>
<td>University of Natural Resources and Life Sciences (BOKU), Vienna, Austria</td>
<td>Agricultural Economics</td>
<td>2014 to 2018</td>
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<tr>
<td>Master (M.) – 1st Division</td>
<td>Amity University, Uttar Pradesh, India</td>
<td>Finance</td>
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<tr>
<td>Master of Science (Msc)</td>
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<td>Agribusiness Management</td>
<td>2007 to 2009</td>
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<tr>
<td>Bachelor of Science (Bsc) – 1st class</td>
<td>Makerere University Kampala, Uganda</td>
<td>Agronomy</td>
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3) Fields of interest

- Agribusiness management  
- Organic agriculture  
- Project management  
- Sustainability assessments  
- Rural development  
- Standards and certification

4) Working experience

<table>
<thead>
<tr>
<th>Dates</th>
<th>Position</th>
<th>Location</th>
<th>Duties &amp; Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 2014 to June 2017</td>
<td>PhD Researcher</td>
<td>Research Institute of Organic Agriculture/FiBL, Switzerland</td>
<td>Researcher - Sustainability assessments</td>
</tr>
<tr>
<td>March 2012 to March 2014</td>
<td>Programme Coordinator</td>
<td>International Rescue Committee, Kampala, Uganda</td>
<td>Project Leader, Economic Development and Livelihoods</td>
</tr>
<tr>
<td>March 2011 to March 2012</td>
<td>Consultant</td>
<td>Farmgate Services Ltd, Kampala, Uganda</td>
<td>Advisor for projects and companies</td>
</tr>
<tr>
<td>January 2010 to March 2011</td>
<td>Trainer</td>
<td>Research Institute of Organic Agriculture/FiBL, Switzerland</td>
<td>Co-editor/Co-author, Africa Manual project</td>
</tr>
</tbody>
</table>
January 2007 to December 2009  | Module Facilitator  | Uganda Martyrs University, Nkozi, Uganda  | Facilitating ‘Agro-product development’ and ‘Agricultural Marketing’ modules
January 2007 to December 2009  | Operations Manager  | Amfri Farms Ltd/ African Organic  | Managing overall business operations
August 2003 to January 2007  | Production Manager  | Amfri Farms Ltd/ African Organic  | Managing on farm production and processing activities

5) PhD courses attended elsewhere

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>Location</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>21st-24th April 2015</td>
<td>PhD course*</td>
<td>IAMO, Halle/Saale, Germany</td>
<td>Efficiency and Productivity Analysis 1 – Deterministic Approaches</td>
</tr>
<tr>
<td>13th April -17th April 2015</td>
<td>PhD course*</td>
<td>IAMO, Halle/Saale, Germany</td>
<td>Agent-based Modelling in Agricultural and Resource Economics</td>
</tr>
<tr>
<td>23rd – 27th March 2015</td>
<td>PhD course*</td>
<td>Bonn University, Germany</td>
<td>Applied Advanced Econometrics</td>
</tr>
<tr>
<td>16th – 20th March 2015</td>
<td>PhD course*</td>
<td>Goettingen University, Germany</td>
<td>Efficiency and Productivity Analysis 2 – Stochastic Approaches</td>
</tr>
<tr>
<td>16th – 21st February 2015</td>
<td>PhD course*</td>
<td>IAMO, Halle/Saale, Germany</td>
<td>Foundations of Agricultural Economics: Selected Topics</td>
</tr>
<tr>
<td>1st September -17th December 2014</td>
<td>PhD course PNS0112</td>
<td>Swedish University of Agricultural Sciences (SLU)</td>
<td>Interdisciplinary Research in Practice – Exploring future agriculture and land use</td>
</tr>
</tbody>
</table>

* Doctoral Certificate Program in Agricultural Economics (http://www.agraroekonomik.de/Doctoral_program/)

6) Conference list

<table>
<thead>
<tr>
<th>Date</th>
<th>Course/conference</th>
<th>Location</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th -14th December 2016</td>
<td>International Conference on Agri-Chains and Sustainable Development: linking local and global dynamics</td>
<td>CIRAD/Le Corum, Montpellier, France</td>
<td>Methods and challenges in assessing sustainability in agri-chains</td>
</tr>
</tbody>
</table>

7) Publication list

**Peer-reviewed**


Non-peer reviewed


http://www.harper-adams.ac.uk/events/ifsa-conference/papers/2/2.2%20Ssebunya.pdf


