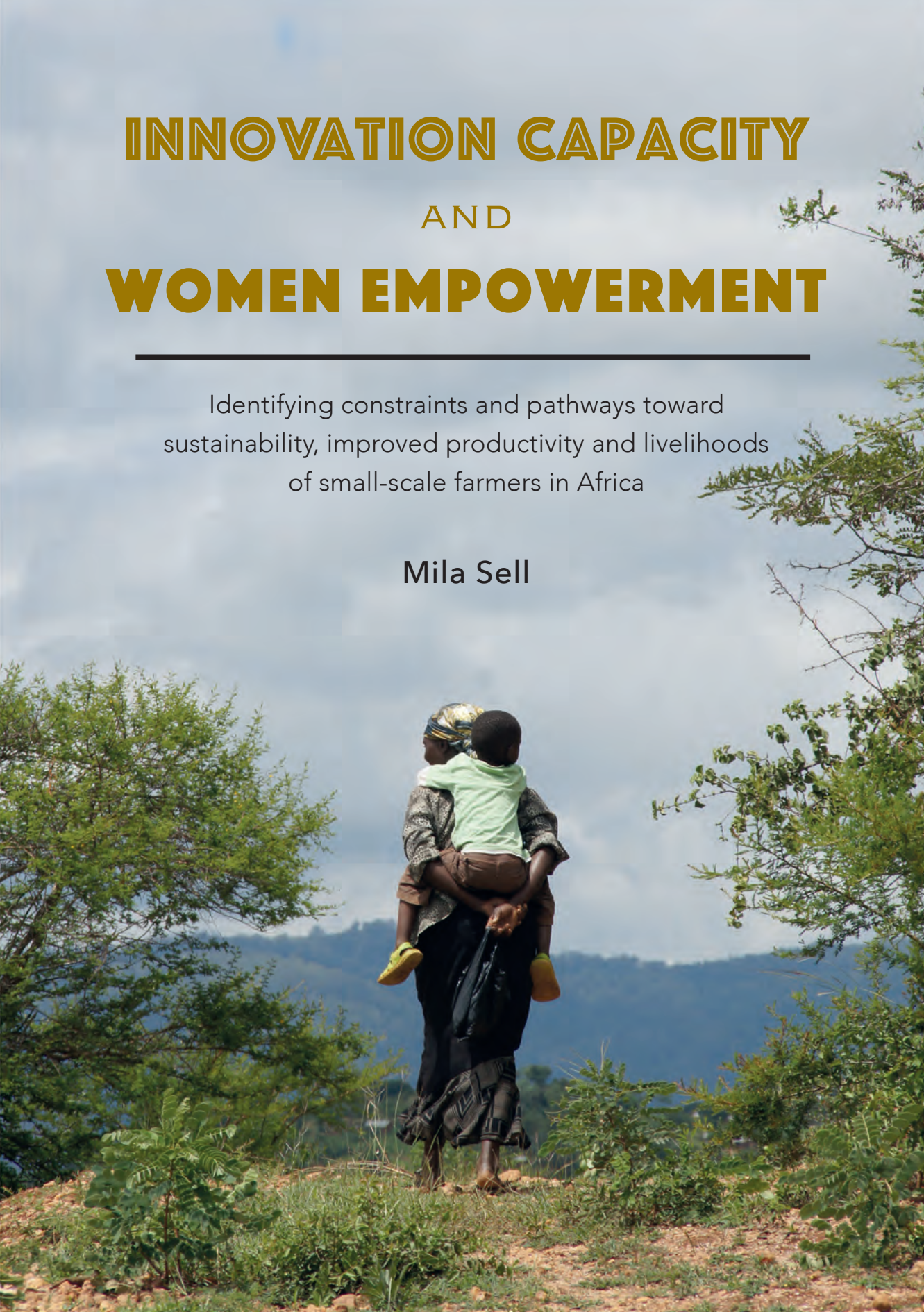
INNOVATION CAPACITY AND WOMEN EMPOWERMENT

Identifying constraints and pathways toward sustainability, improved productivity and livelihoods of small-scale farmers in Africa

Mila Sell



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Mila Sell

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Identifying constraints and pathways toward sustainability, improved productivity and livelihoods of small-scale farmers in Africa

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Abstract

This thesis approaches some of the global challenges of the coming decades, including climate change, biodiversity loss, growing populations, and food insecurity, from a small-scale farmer's perspective. In Africa small-scale farmers still account for up to 70% of the population, and represent the poorest and most vulnerable group to these challenges. They are, however, a heterogeneous group with various problems and needs. Sustainably improving their situation will require context-specific solutions developed through an innovation process, in which local needs and voices are heard and taken into consideration.

Active participation in the Innovation System requires innovation capacity and empowerment. This is especially crucial for women farmers, who face a number of additional constraints compared to their male counterparts. This difference in constraints is commonly referred to as the *gender gap*. There is a gender gap in access to resources such as land, inputs, labour and credit, but also in access to education, training, and rights. Supporting small-scale farmers, especially women farmers, can positively influence productivity and contribute to better wellbeing of whole families.

The aim of this thesis is to identify and understand the determinants of some of these gender-related constraints, as well as to discuss some of the possible pathways towards more equal and sustainable systems. It consists of three papers, each describing an empirical study of the challenges affecting small-scale farmers, from a particular approach. Both quantitative and qualitative methods are used. Triangulation allows us to see both context-specific cases, but also the many common trends and underlying rules that drive these processes.

Papers I and II are based on a large-scale household survey from Uganda, for which data was collected from 1440 households. The analyses use econometric modelling to identify patterns and constraints of women farmers. Paper I focuses on characteristics of farm households associated with women empowerment, a methodology inspired by the Women Empowerment in Agriculture Index (WEAI).

We use decision-making as the main determinant to define empowerment. The results suggest that empowerment is significantly influenced by age, but also by the size of the household, and particularly the number of children under five. This is related to the time burden that household work puts on women. Another significant variable is educational equality, suggesting that the larger the difference in education between the spouses, the lower the level of female empowerment.

Paper II uses a stochastic frontier analysis (SFA) to compare the efficiency of women farm managers, to that of male or jointly managed farms, and to identify the determinants of inefficiency of women managers. We find a statistically significant difference in efficiency between the different groups – women managing plots less efficiently than their male counterparts or the jointly managed plots. Also in this case we find that household-related time burden has negative consequences. Women working outside the household, on the other hand, was positively associated with efficiency. We argue that supporting women to participate more actively in income generating activity may have a positive impact on household wellbeing.

Paper III describes a participatory pilot study in Ethiopia, in which an Innovation Platform (IP) was established. The paper evaluates the IP methodology based on qualitative data collected through two surveys, focus group discussions, IP meeting reports and key informant interviews. The study analyses the IP activity from a co-creation approach, focusing on the experiences of the participants. We found that participating in the innovation system, through the IP tool, allows especially women farmers to be actively involved. They all reported that their role as communicators and model farmers in the community was strengthened. Using IP methodology as a tool of the extension system could potentially benefit women empowerment as well as livelihoods.

The three papers all focus on issues relating to food security, sustainable productivity, livelihoods and wellbeing of small-scale farmers in Africa, although the individual studies have different methodologies and approaches. The summarising chapter of the thesis takes all

three studies and includes them under a joint theoretical framework. The research questions of the overall thesis therefore take a holistic approach, and attempt to respond to the following questions:

1. What are the key aspects or characteristics of women empowerment among small-scale farmers?
2. How do these characteristics relate to the productivity and efficiency of farming practices of men and women?
3. How can participation in the innovation processes support small-scale farmers', particularly women farmers', empowerment, productivity and visions for the future?
4. How can these approaches be used to develop pathways towards sustainability?

The results are formulated as different pathways towards the overall goal of improving small-scale farmers' wellbeing. The aim is creating sustainable farming systems that increase productivity while improving equality and empowerment.

The key promising pathways identified include: increasing education, developing opportunities for non-farm income generating activities, supporting women farmers' market-based agriculture, and supporting equality and women's empowerment through co-creation and Innovation Platform methods.

Education of women and girls is essential in order to reach the overall goal. However, increasing women's empowerment will also require educating men and boys, as a gender gap in education was found to have negative implications. It will be important to focus on different types of education, at different levels. In some cases technical extension training is more relevant than actual formal education. But good basic knowledge is a pre-requisite also for this, and finding ways to keep girls in school is considered a central pathway.

It is an issue related to equality and empowerment. Empowered girls and women are also more likely to get involved in various non-farm income-generating activities outside the household, which in turn is likely to increase wellbeing. Supporting women in developing market-oriented agriculture is also important. Farmer groups, especially

women farmer groups, may have an important role to play. One method for supporting these groups is using Innovation Platforms.

Therefore, one of the main recommendations of this thesis is a methodological one. It is a pathway suggesting integration of Innovation Platforms into current extension systems. This will allow different stakeholders to collaborate and participate in co-creation of local solutions to local problems.

Tiivistelmä

Tämä tutkimustyö käsittelee afrikkalaisen pienviljelijän kykyä sopeutua tulevina vuosikymmeninä edessä oleviin globaaleihin haasteisiin kuten ilmastonmuutokseen ja biodiversiteetin vähenemiseen, jotka yhdessä väestönkasvun kanssa uhkaavat heikentää ratkaisevasti ruokaturvaa.

Pienviljelijät, jotka muodostavat edelleen noin 70 % Afrikan väestöstä, edustavat usein kaikkein köyhintä ja ruokaturvan näkökulmasta haavoittuvinta väestöryhmää. Viljelijöiden kohtaamat haasteet ja tarpeet vaihtelevat kuitenkin niin paljon, että vaaditaan vahvasti olosuhteisiin sopeutettuja ratkaisuja, joita viljelijöiden ja heidän sidosryhmiensä tulisi luoda osana innovaatioprosessia.

Innovaatiosysteemi voi koostua useista erilaisista innovaatioprosesseista. Osallistuminen näihin prosesseihin vaatii sekä voimaantumista (empowerment) että käytännön innovaatiokapasiteettiä. Tämä on tärkeää erityisesti naisviljelijöille, sillä he kohtaavat miehiä enemmän osallisuuteen ja päätöksenteko-oikeuteen liittyviä haasteita. Naisviljelijöiden toimintaa rajoittavat muun muassa maanomistuksen säätely sekä työvoiman ja luoton saatavuus, mutta myös perusoikeuksien, kuten koulutukseen pääsyn heikko toteutuminen.

Tämän tutkimuksen yleisenä tavoitteena on luoda kestäviä maatalousjärjestelmiä, jotka lisäävät tuottavuutta parantaen samalla tasa-arvoa ja voimaantumista. Tarkempina tavoitteina on tunnistaa ja analysoida afrikkalaisten pienviljelijöiden sukupuoleen liittyviä osallisuuden rajoitteita sekä löytää mahdollisia kehityspolkuja kohti oikeudenmukaisempaa ja ruokaturvan kannalta kestävämpää järjestelmää.

Väitöstutkimus koostuu kolmesta osajulkaisusta. Osajulkaisut I ja II hyödyntävät Ugandassa vuosina 2012 – 2013 kerättyä laajaa aineistoa yhteensä 1440 kotitaloudesta. Osajulkaisussa I tarkastellaan naisviljelijöiden voimaantumista hyödyntäen, mutta myös edelleen kehittäen, *Women Empowerment in Agriculture Index* (WEAI) – arviointimenetelmää. Naisviljelijöiden työtä ja sen rajoitteita sekä

erilaisia käyttäytymismalleja tarkastellaan käyttäen ekonometristä mallinnusta. Tutkimuksen tulokset osoittavat, että voimaantumista lisäävät naisen ikä ja työskentely kodin ulkopuolella sekä koulutuksellinen tasa-arvo puolison kanssa. Voimaantumista vähentäviä tekijöitä ovat kotitalouden suuri koko sekä alle viisi vuotiaiden lasten lukumäärää, jotka molemmat lisäävät naisen kotitöiden taakkaa.

Osajulkaisu II vertaa nais- ja miesviljelijöiden sekä yhteisesti viljeltyjen palstojen tehokkuutta hyödyntämällä *Stochastic Frontier Analysis* (SFA) -menetelmää. Tulosten mukaan naisten viljelemien palstojen tuotannollinen tehokkuus on alhaisempi kuin miesten palstojen tai yhteisesti viljeltyjen palstojen tehokkuus. Ero selittyy kotitöiden naisille aiheuttamalla lisätaakalla. Sen sijaan naisten työskentely ansiotyössä maatalouden ulkopuolella lisää yleisesti tuotannollista tehokkuutta myös naisten hallussa olevilla palstoilla. Tulokset tukevat aiempia havaintoja siitä, että naisten työllistyminen maatalouden ulkopuolelle vaikuttaa myönteisesti kotitalouksien hyvinvointiin.

Osajulkaisu III kuvaa Etiopiassa tehtyä pilottitutkimusta, joka hyödyntää uutta *Innovation Platform* -menetelmää. Hankkeessa kerättiin laadullista aineistoa, jonka perusteella innovaatiotoimintaa ja käytettyä menetelmää voitiin arvioida. Tulokset osoittavat, että *Innovation Platform* -menetelmä tarjoaa erityisesti naisille mahdollisuuden osallistua aktiivisesti innovaatiotoimintaan, ja että osallistuminen on voimaannuttavaa.

Laajemmassa teorettisessa viitekehyksessä kaikki väitöstutkimuksen kolme osajulkaisua tarkastelevat afrikkalaisen pienviljelijän näkökulmasta ruokaturvaan, kestävään tuotantoon, elantoon ja hyvinvointiin liittyviä kysymyksiä käyttäen erilaisia tutkimusmenetelmiä ja lähestymistapoja. Tutkimuksen yhteenveto-osassa vastataan holistisesta näkökulmasta seuraaviin kysymyksiin:

1. Mitkä pienviljelijöiden ominaisuudet vaikuttavat keskeisesti naisten voimaantumiseen?
2. Miten nämä ominaisuudet liittyvät mies- ja naisviljelijöiden tuottavuuteen ja tehokkuuteen?

3. Miten osallistuminen innovaatioprosesseihin tukee pieniviljelijöiden, erityisesti naisviljelijöiden, voimaantumista, tuottavuutta ja tulevaisuuden näkymiä?
4. Miten näitä lähestymistapoja voidaan hyödyntää, kun luodaan polkuja kohti kestävää kehitystä?

Tämän tutkimuksen mukaan naisviljelijöiden markkinalähtöisen maatalouden kehittäminen luo naisille tuloja, jotka hyödyttävät yhteisöä laajemmin. Tutkimuksen mukaan *Innovation Platform* – menetelmällä voidaan tehokkaasti tukea afrikkalaisia naisviljelijöitä ja naisviljelijöiden ryhmiä. Menetelmä lisää eri sidosryhmien yhteistyötä ja luo ratkaisuja ajankohtaisiin paikallisiin haasteisiin. *Innovation Platform* -menetelmä tulisi jatkossa integroida osaksi nykyisiä maatalouden neuvontajärjestelmiä.

Tutkimuksen tulokset korostavat koulutuksen merkitystä. Koulutuksella on yhteys sekä tasa-arvoon että naisten voimaantumiseen. Molemmat lisäävät osallistumista palkkatyöhön kotitalouden ja maatalouden ulkopuolella, mikä vuorostaan parantaa kotitalouksien hyvinvointia ja luo polkuja kohden kestävää kehitystä.

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Thank you all!

Contents

List of abbreviations

AIS	Agricultural innovation systems
AKIS	Agricultural knowledge and information systems
ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
ECA	Economic Commission for Africa
ESS	Ethiopia Socioeconomic Survey
FAO	Food and Agriculture Organiation of the United Nations
FOWODE	Forum for Women and Democracy
GDI	Gender-related development index
GDP	Gross domestic product
GEM	Gender Empowerment Index
HDR	Human Development Report
IFPRI	International Food Policy Research Institute
IP	Innovation Platform
LSMS	Living Standard Measurement Study
MDG	Millennium Development Goals
OECD	Organisation for Economic Co-operation and Development
OPHI	Oxford Poverty and Human Development Initiative
RCT	Randomised control trial
SARI	Southern Agricultural Research Institute
SDG	Sustainable Development Goals
SFA	Stochastic frontier analysis
SSA	Sub-Saharan Africa
TE	Technical efficiency
UBOS	Uganda Bureau of Statistics
UNDP	United Nations Develoment Programme
USAID	United States Agency for International Development
WCED	World Commission on Environment and Development
WEAI	Women Empowerment in Agriculture Index
WEF	World Economic Forum

List of original publications

1. Sell, Mila and Nicholas Minot (2018). What factors explain women's empowerment? Decision-making among small-scale farmers in Uganda. *Women's Studies International Forum*, 71. 46-55.*
2. Sell, Mila, Stefan Bäckman, Benjamin Anang and Jarkko Niemi (submitted). The Unequal Efficiency Gap: Key Factors Influencing Women Farmer's Efficiency in Uganda. *Cogent Food & Agriculture*. Accepted for Publication, November 13, 2018.**
3. Sell, Mila, Hilkka Vihinen, Galfato Gabiso and Kristina Lindström (2018). Innovation Platforms: a tool to enhance small-scale farmer potential through co-creation. *Development in Practice*. Published online 30 August, 2018.***

*Mila Sell is the first author of the paper, responsible for designing the gender component, based on the Women Empowerment in Agriculture Index (WEAI), analysing the data, and writing the bulk of the paper. Nicholas Minot was responsible for the overall research project in Uganda and in addition contributed to this papered through important editing and revision.

**Mila Sell is the first author of the paper responsible for designing the gender component of the survey, analysing the data, and writing the bulk of the paper. Stefan Bäckman and Benjamin Anang from the University of Helsinki and Jarkko Niemi from Luke have provided essential input into design and implementation of the stochastic frontier analysis as well as participating in editing and revising the paper.

***Mila Sell is the first author of the paper, responsible for designing the action research component of the Soilman project and establishing the Innovation Platform, analysing the data, and writing the bulk of the paper. Prof. Kristina Lindström was the lead researcher of the Soilman project who, together with Prof. Hilkka Vihinen, has been involved in editing and revising the paper. Galfato Gabiso from Hawassa University was the facilitator of the Innovation Platform, handling the practical implementation of the field activities, including reporting from IP meetings.

1 Introduction

A recent manifesto titled *World Scientists' Warning to Humanity: a second notice*, signed by more than 15 000 scientists from around the globe, attempts to wake up people and politicians around the world to the fact that we are very close to the tipping points for what the earth's natural systems can withstand (Ripple et al. 2017). Climate change and biodiversity loss are two of the most critical challenges humankind is faced with. The only way forward is a *sustainability transition*, which, in addition to political will and leadership, will require a range of new approaches and practices. It will require context specific solutions as well as new models for collaboration between various different stakeholders.

One of the major contributors to climate change, biodiversity loss, soil erosion and nutrient depletion, (highlighted also in the manifesto), is agriculture, although agriculture can also contribute to many of the solutions. Growing populations and growing demands on meat-based diets exacerbate the problem. In high and middle-income countries, the main problems are over-consumption, food waste, and unsustainable agricultural practices. In poor countries, including most of Africa, on the other hand, food security is a major problem. The Millennium Development Goal (MDG) to half the amount of hungry in the world by 2015 was already on track to be achieved, but today the number of hungry people is again on the rise in some sections of the world population. To a large extent this is due to inequalities underlying hunger (GHI 2017). Sustainable Development Goal (SDG) number two, to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" (UN 2015), has replaced the MDG to continue this global effort. However, there are still more than 800 million undernourished people in the world. Close to 30 percent of them live in Africa (GHI 2017).

Food security is a basic human right and the prerequisite for wellbeing and meaningful development. Only people who are well nourished have the capacity to improve their situation and the lives of their children.

Even with a clear trend towards urbanisation around the world, more than 60 percent of the population in Africa still live in rural areas and are involved in farming for their income (FAO 2011). This is especially true for rural women, who are also the ones to produce the bulk of the locally consumed food in Africa (World Bank 2009). The farming practices of these small-scale, resource-poor farmers are often inefficient and do not provide a secure livelihood. Therefore, supporting small-scale farmers in increasing their productivity in sustainable ways is a key challenge.

Women farmers in Africa are faced with many gender-specific constraints compared to male farmers, often referred to as the *gender gap* (FAO 2011). Gender is by no means the only constraining factor, as a range of other context specific issues influence the performance and opportunities of small-scale farmers. However, gender has been identified as an important determinant of rights, resources and responsibilities, both within and outside the household (Quisumbing and McClafferty 2006). According to the FAO women could increase their yields by as much as thirty percent if guaranteed equal access to inputs such as land, seed and fertilizer, extension services and markets (FAO 2011). Understanding the determinants of the gender gap is therefore central in order to develop meaningful policy, guidelines, recommendations and action that better supports women farmers. It is also essential to involve local farmers and other stakeholders as active participants of the innovation system. Sustainable local solutions need to be developed through an innovation process where local needs and voices are taken into consideration. An innovation systems approach allows people to identify and develop local solutions to local problems (Adjei-Nsiah et al. 2013). The *pathways* developed through such a process have the greatest potential to bring about sustainable change.

But in order to participate in innovation processes people need to have innovation capacity, which requires a certain level of agency and empowerment. Women empowerment has had an important role on the scientific and development agenda in the past decades. However, more needs to be learned and understood, especially through context-specific cases, to guide local processes towards sustainability.

This thesis looks at several of the above mentioned challenges through an integrated approach. It aims to contribute to sustainable development through identifying possible solutions or pathways, based on empirical case studies from Uganda and Ethiopia. The term *pathways* is used throughout this thesis to refer to strategies towards more sustainable practices, based on a number of tools, methods and solutions identified through the studies. The specific cases relate to challenges of small-scale farmers, especially women farmers, identifying ways of improving efficiency, productivity, livelihoods and well-being. In the long-term the pathways are expected to contribute towards a sustainability transition, which here is defined as a deeper process of societal change. Gender and empowerment are cross-cutting themes of the thesis.

2 Aims and Objectives of the Thesis

In order to support small-scale farmers in transitioning towards more sustainable practices, it is essential to identify the key constraints and inhibiting factors which they are faced with. This is the overarching goal of this thesis. It consists of three papers, each describing a case-study relating to these questions (hereafter referred to by the roman numbers I, II, and III). Papers I and II are based on a large-scale household survey from Uganda, paper III on a participatory pilot study in Ethiopia. The empirical projects study factors affecting small-scale farmers from different perspectives, with different methods, both quantitative and qualitative. This multidisciplinary approach uses triangulation which allows us to see both the context-specific challenges, but also the many common trends and drivers that influence these processes. Some of these are relevant also to contexts beyond the communities involved in the studies, and can thereby contribute insight and lessons learned for a wider audience of scientists and development practitioners.

The papers focus on issues relating to food security, sustainable productivity, livelihoods and well-being of small-scale farmers in Africa. The research questions are based on a joint conceptual framework (Fig. 1), described in chapter four of the thesis. The results and

responses to the research questions are thus at different levels, even as they respond to thematically related issues and scenarios.

A key cross-cutting theme of the thesis is the role of women in African agriculture. Naturally, there are countless different stories, experiences and realities that shape these roles in different geographical, social and cultural contexts. The studies included in this thesis touch upon a few of them. The aim is to identify the constraints of women in relation to a few specific aspects of farming based on our case studies. These include identifying the determinants of women empowerment in the household, factors affecting efficiency, and women's innovation capacity and potential as knowledge brokers in the agricultural innovation system.

Each of the studies described in the papers have their own specific research questions. The overall research questions of this thesis are;

1. What are the key aspects or characteristics of women empowerment among small-scale farmers?
2. How do these characteristics relate to the productivity and efficiency of farming practices of men and women?
3. How can participation in the innovation processes support small-scale farmers', particularly women farmers', empowerment, productivity and visions for the future?
4. How can these approaches be used to develop pathways towards sustainability?

Paper I responds directly to the first research question, focusing on the characteristics of women empowerment. Using data from Uganda it identifies the links between empowerment and other characteristics of the individual, the household, as well as a few community factors. Paper II looks at differences in efficiency, and the determinants of efficiency, between plots farmed by men and women, thereby providing answers to the second research question. The study uses the same data from Uganda as paper I and it is therefore possible to reflect upon links between empowerment and efficiency. Paper III responds to the third research question, by describing the results from a qualitative participatory study in Ethiopia. An Innovation Platform (IP) is set up to test participatory ways of integrating

new technology into the local farming system. In addition to the adoption of the technology, the study analyses the experience of the method and the implications it has for participation and empowerment. Through the insights relating to empowerment, paper III also contributes to research question one. Promising pathways towards sustainability, in response to the fourth research question, will be discussed based on results from all three studies.

The goal of each case study is to contribute to the understanding of issues affecting small-scale farmers, especially women, in order to identify promising research-based policy recommendations. These recommendations can be useful for a range of stakeholders, from local and national policy makers, extension actors, NGOs and development practitioners. The results shed light on some of the underlying patterns that define the boundaries and determinants of farmers' realities, with a special focus on women farmers in the given context. Although the results are based on individual studies, they provide insights into some of the structures that contribute to the challenges of small-scale farmers as well as the gender gap. These insights are instrumental in developing pathways and tools to tackle the key overarching questions. The pathways developed in this thesis are based on the results of the three studies, suggesting different methodological approaches towards empowering (women) farmers. The pathways can be adapted to and integrated into various different contexts.

The contribution of the study is thus both theoretical and practical. The scientific contribution is providing insight into some of the current factors affecting small-scale farmers, specifically relating to the gender gap and changing role of women. Raising awareness of these factors among development practitioners is also important. The thesis also introduces some transdisciplinary theoretical and methodological tools for doing so. The practical contributions of the study are the recommendations for policy, development projects and future research that the pathways provide.

3 Conceptual and Theoretical Background

The global food system is facing a major sustainability crisis. It is currently unable to fulfil its main task, that is, providing enough nutritious food for all people. Food security is a concern from a number of political and scientific points of view. It is the key focus of the agricultural sector, ranging from issues relating to production, post-harvest measures and technology, all the way via markets to the consumers. But it is also a concern of scientific fields focusing on health and nutrition, as well as socio-economics and well-being. This thesis approaches the issue from an agricultural science point of view, but through a socio-economic, human-centred lens.

The work is situated in the intersection between sustainability, food security, efficiency, innovation and empowerment of women farmers in Africa. There are numerous theoretical and methodological approaches, from various different scientific fields, that could be relevant for this study. It is impossible to address all of them here. The section below will cover the areas that have been most influential in informing the research, methods and analysis of the studies featured in the different papers of this thesis, as well as the overall conceptual framework.

Starting from a discussion on the challenges of small-scale farmers, particularly women farmers in Africa and the gender gap they are faced with, the chapter continues to discuss an Innovation System approach and how that can be instrumental in finding solutions for farmers. Next, the focus turns to a range of methodological issues, including ways to measure empowerment (paper I) and efficiency (paper II). These research questions are multidisciplinary by nature, and closely linked to a range of different scientific fields. Many of the key research questions are tackled within economics, more specifically agricultural economics, which is also the overarching scientific field under which this thesis falls, often using econometric approaches and analysis tools. But using an Innovation Systems approach in agricultural economics means integrating many aspects from behavioural science in the analysis. These include aspects of

learning, agency, empowerment and community participation. All of these approaches, as well as the overall aim of the thesis, are further closely linked to *sustainability science*.

The thesis recognises the importance of a sustainability approach to any work done involving humans and their relationship to natural resources. Finding methods and tools to improve sustainability, both natural and social, is one of the overarching goals of the thesis. In the context of this thesis the methods and tools are referred to as pathways.

The concept of pathways is commonly used by development and research for development actors. Within the literature on impact assessment, 'impact pathways' are used to identify the overall impact of for example an agricultural programme (Ainembabazi et al. 2018, Schuetz et al. 2017). Impact pathways often aim to define (either ex-ante or ex-post) the causal relationship between technology and welfare outcomes, or how the gap between research outputs and outcomes in development can be bridged (Schuetz et al. 2017).

In an African context this often means studying pathways towards agricultural transformation. For example Bachewe et al. (2018) provide a number of, what they refer to as pathways towards (rapid) agricultural growth. These are in fact major structural changes, such as changes in information efficiency and the role of agriculture extension, changes in input and output market efficiency, and changes in human capital accumulation (Bachewe et al. 2018). These are pathways developed in response to given constraints that can only be achieved through active (policy) actions or interventions. Such an intervention can be promoting of livestock development, often referred to as a 'pathway out of poverty' (Ehui and Pender 2005).

However, there is also literature that uses the concept of pathways to refer to individual, household level strategies (Muyanga et al. 2013). The main difference is the focus on the farmers themselves and their capacity to develop or maintain strategies influencing household wellbeing. This capacity is influenced by household wealth status, which in turn affects the accumulating of new assets, but also by the demographic and economic characteristics of prior

generations (Muyanga et al 2013). Other key issues include educational attainment, health setbacks and social capital and connections.

This thesis uses the concept to refer to both levels, that is, pathways at a structural level that will require political engagement, and to local strategies that individual farmers can actively participate in and contribute to.

3.1 Challenges of small-scale farmers in Africa

According to the Rome Declaration from 1996, "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). In practice this means that people should have stable and secure access to food, either by producing food themselves or through a stable income with which to buy food, as well as the means to prepare it for utilisation. Many African small-scale farmers struggle to achieve this, due to the many constraints they are faced with.

In the agricultural development literature concerning Africa the concepts of small-scale or small-holder farms are commonly used. Few peer-reviewed journal articles give a specific definition of what they mean by the concept, although classifications based on the size of the household's farmed land are sometimes used (Chamberlin 2008). The discussions do, however, point to certain common features associated with small-scale farming. These include the notion that small-scale farming is generally rural and peripheral, characterised by low input use, weak market links (Chamberlin 2008, Jayne et al. 2016, Schindler et al. 2017) and high risk-averseness, preventing investments in new technology (Ihli et al. 2018). In addition to being land constrained, the challenges of this type of 'traditional small-scale production' (Mercado et al. 2018) relate to short supply chains, where the activity takes place mostly outside formal markets.

Of course, small-scale farmers in Africa are by no means a homogenous group. There are vast differences in the constraints and

opportunities these farmers are faced with (Chamberlin 2008). Their realities vary based on a range of context-specific issues, including climatic factors, social and political realities and the support systems that may or may not be present in their local community. All these issues will have an effect on the extension support and knowledge available, as well as the access to credit, inputs and markets. Issues such as average size of farmland, ownership structures, household composition and access to labour, will significantly affect the performance of the farm. Together these factors contribute towards the existence or lack of an enabling environment to support farmers (Adjei-Nisah et al. 2013).

However, despite these differences, the fact still remains that a majority of African farmers lives in rural areas, engage in rain-fed agriculture, without additional sources of income (Röling 2010). The small amounts of money they are able to gain from selling a surplus, does not provide financial security. Therefore, it is not surprising that seventy percent of people who persistently struggle below the poverty line live in rural areas (Röling 2010).

Many of the key challenges of small-scale farmers are related to lack of access and lack of resources. The lack of resources hinders investment in sustainable practices and transformation towards smarter agricultural systems. The lack of resources is in many ways linked to access. Poor farmers tend to lack access to markets, both for selling their produce, but also for accessing high-quality inputs, including crop varieties (Hill and Vigneri 2009).

This will severely affect their livelihood opportunities. Livelihoods is a term describing peoples means of securing their basic requirements for wellbeing, including food, water, shelter and clothing. In addition to material resources, this requires a certain level of capacity and ability, including human, social and financial assets (Abraham and Martin 2016). Thus livelihoods play an important role for sustainable rural development, closely related to issues such as poverty and food security (Baumgartner 2004). In rural contexts it is often assumed that livelihoods are directly linked to agriculture and natural resources, but it is important to understand the various

diversification strategies that rural households may adopt (Ellis 2000). This becomes increasingly important when livelihoods are caught in conflicts of social, economic and environmental ambitions. The term 'livelihood resilience' is increasingly used in international development discourse. It brings the analysis of livelihoods to a household level where human agency and people's capacity to cope with shocks plays a key role (Quandt 2018).

In the context of this work, livelihoods are important as potential pathways to sustainable alternatives to subsistence farming. If capacity and opportunities of small-farmers are improved it can lead to new livelihood options both within market-oriented agriculture, but also through non-farm income generating activity. This may have important implications for household wellbeing as well as for the sense of empowerment of the farmers themselves.

There are significant differences also between the opportunities and challenges of different individuals and groups (see chapter 3.7 Empowerment, for a discussion on Amartya Sen's capability approach). A range of evidence shows that the role of women in agriculture directly contributes to local food security, nutritional diversity, and household wellbeing, but that in many cases women farmers are disadvantaged, compared to their male counterparts (Lambrecht et al. 2017). The discourse on supporting small-scale farmers doesn't always take into consideration the implications of gender, or more precisely the effect of gender equality on well-being, although a gender gap in agriculture is quite frequently referred to in the literature (FAO 2011).

Another challenge, when studying women farmers' realities in particular, is that it is often difficult to capture the diversity, complexity and contradictions evident in rural women's lives. Rural social theories often inadequately address the effects of issues such as environmental stress and degradation, and the implications of agricultural intensification on gender relations (Sachs 2018). Feminist theory may be better at recognising the role women play in creating and shaping rural life, as active agents. This approach tackles questions such as understanding the relationship of women with their natural

environment, distinguishing the patriarchal relations in the countryside, identifying the effects of global economic restructuring on rural women as well as recognising the strategies women use for shaping their lives (Sachs 2018).

Without basing the work on any specific feminist theory, these questions become relevant also for the studies in this thesis. The decision-making aspect of empowerment, studied through the WEAI, provides an understanding of the patriarchal relations. Women's experiences of market access, reflects experiences also at larger-scale economic structures. The pathways identified in the study may be examples of the local strategies women adopt, for example establishing women's groups or organisations.

3.2 The Gender Gap

In a number of scientific fields, the concept of 'gender gap' has become an important theoretical tool for discussing inequality between men and women, as gender differences have been identified as important causes of disparities in development outcomes (Quisumbing and McClafferty 2006). In most cases the gender gap measures women's disadvantage in relation to men. It is a measure of gender imbalance which measures gaps rather than levels, and so does not say anything about the actual levels of e.g. empowerment (or agricultural production or education) (World Economic Forum 2017). For example World Economic Forum reports on the Global Gender Gap on a yearly basis, comparing national levels within different sectors. Their focus is on factors such as health, education, economic participation and political empowerment (World Economic Forum 2017). The index disassociates gaps in equality from the level of development of the country.

Much of the literature on which the theoretical background of the gender gap relies is related to economics, commonly focusing on gender-wage gap, or gender gap in paid work. One of the main background theories is an 'efficiency argument', suggesting that higher employment rates will widen the human capital base, which in turn is assumed to increase competitiveness. This approach sees women

as an untapped market resource (Plantenga 2015). Often such a 'human-capital model' focuses on gender differences in qualifications, based on abilities and skills acquired through education, training and experience (Grybaite 2006). Looking at the gender gap in education is therefore an important focus of many studies.

A similar economic 'business case' approach is used to promote the reduction of the gender gap in agriculture, in order to improve efficiency and productivity (Manfre et al. 2013). But also other drivers for decreasing the gender gap in agriculture exist. The 'development case' assumes that minimising the gap will improve food security, reduce poverty, and improve household nutrition. Decreasing discrimination is also seen as a value in itself (Manfre et al. 2013)

Many of the underlying reasons for the gender gap can be found within discriminatory social institutions. These may be either formal or informal and include laws, policies, norms, and social practices that restrict women's participation, opportunities and rights (OECD 2015). Many such informal social institutions are highly influenced by the gender roles and norms defined and accepted by the community (Stoebenau et al. 2014). They are shaped based on ideological, religious, ethnic and social determinants (Quisumbing and McClafferty 2006). Therefore, values have a significant role in driving or inhibiting equality. This can be seen also in the economic literature, which commonly suggests women are more risk-averse than their male counterparts (Plantenga 2015). This is attributed to emotional characteristics that make women interpret risk-situations differently compared to men. If such viewpoints are not questioned, gender roles tend to reproduce themselves in society (OECD 2015). That is why it is of such great importance to highlight gender gaps and analyse the underlying reasons. Below, some of the key gender gaps in African agriculture will be summarised briefly, mainly as a means of introduction to the type of challenges that are studied from a gender perspective within agricultural sciences.

Several studies have aimed at identifying the major challenges of women farmers causing the gender gap in agriculture (see for example Hill and Vigneri 2009, Quisumbing and Pandolfelli 2010, Combaz

2013, Gĩthĩnji et al. 2014, Palacios-Lopez et al. 2017). Combaz considers gender inequality a "structural root cause of poverty" (2013). In her report from 2013, based on a large number of case studies about women and girls in market-oriented agriculture in Uganda, Combaz identifies a number of gender-specific factors constraining woman farmers. The most important ones include land ownership, both access and tenure, which directly affect women's possibilities to invest in improved inputs and technologies, division of household labour leading to time constraint for women farmers, as well as unequal decision-making opportunity in the household (Combaz 2013). Women also tend to have less access to and control over other assets that could promote stable pathways out of poverty, such as livestock, equipment and labour (see e.g. Udry's much cited study from 1996, Gĩthĩnji et al. 2014).

Market access is often a constraint for women farmers. Women are less likely to farm cash-crops and tend to produce a smaller surplus – in general, women mainly produce food for household consumption (Hill and Vigneri 2009). The small quantities make them less interesting for the formal markets and exclude them from contract farming in high-value sectors, such as export vegetable markets. They have fewer contacts to traders and networks and therefore less room for price negotiations (Hill & Vigneri 2009). In many African countries women are also less mobile, due both to cultural and practical reasons, and therefore have to accept the lower farm gate prices offered (Combaz 2013). Gĩthĩnji et al. (2014) suggest that women may be more risk averse and therefore less market oriented, prioritizing household food security. This is in line with assumptions made in economic literature, identified by Plantenga (2015). It would be important to try to identify the underlying reasons behind this risk averseness. It is very unlikely to be a gender-specific characteristic, but rather a model adopted due to a number of underlying societal factors.

This is especially important considering the changing dynamics of the agricultural sector. In the past years it has become evident that gender dynamics and roles in agricultural are changing (Doss 2014). Men are more likely to migrate to urban areas in search of job

opportunities, leaving women to take care for both families and crop cultivation. If women are not producing up to their full potential, whether due to risk aversion, lack of access, or other factors, this can have major implications for the wider community, for example leading to or exacerbating food insecurity. According to Combaz over 26 percent of rural households are in practice female headed today. In most cases they are left with less capital and have lower capacity and education, in comparison to male headed households (Combaz 2013). This will likely affect overall productivity of the sector with consequences both for the farmers themselves as well as for urban consumers. It will be the rural women farmers who carry the brunt of the burden, as better off households especially in an urban setting, will still have the means to purchase food.

3.3 Gender-disaggregated data

The methods used in the studies described above provide interesting insight into the methodologies used to approach the topic. A large share of studies tackling gender issues utilize survey data and base their analysis on econometric models (e.g. all of the above studies). This highlights the importance of reliable sex-disaggregated data, and a few words will therefore be said about this. Currently a number of myths and stereotypes get entangled into the debates and discussions regarding the gender gap. It is, for example, commonly claimed that women own two percent of land but produce 80 percent of food (see e.g. World Bank 2009). It is however difficult to find actual data to back up this claim (Doss et al. 2017, Lambrecht et al. 2017).

The fact that not all claims can be verified, however, does not mean there is no truth behind the statements. But more nuanced, accurate, up-to-date, gender-disaggregated data need to be collected in order to identify the actual mechanisms and causes behind the gender gap (Dito 2015). One reason for the lack of data is that until recent years not a lot of reliable, gender disaggregated data has been available. Much more specific data and analysis is needed both for scientific

studies, but also in order to design useful interventions (Lambrecht et al. 2017).

National data, although helpful, does not show the full picture. They tend to include data on the household level, thereby ignoring the fact that different household members may be faced with very different realities and opportunities. Models based on assumptions about intra-household dynamics, are very likely to lead to flawed policy recommendations (Agarwal 1997). There are also a number of important sub-national and regional disparities. Societal and institutional structures can have a major impact on women's economic status and opportunities. But also local culture and local networks, formal as well as informal, play a significant role (Dito 2015). Therefore local solutions are needed, designed based not on national statistics, but on concrete case-specific realities.

To analyse these differences and their effect on productivity, many studies investigate the gender gap through intra-household studies. They try to identify the drivers and magnitude of the gender gap. Ali et al. (2016) however argue that many such studies are problematic. It is challenging to systematically identify and explore all relevant covariates that contribute to the gender gap. Fortunately there are alternative approaches to understanding the challenges of small-scale farmers. 'Innovation systems thinking' is one of these approaches. The next section will therefore introduce the concept and discuss how it has developed and what it has and can contribute to the understanding of African small-scale farmers' realities.

3.4 Innovation Systems Approach

The past decades have seen a criticism of traditional extension systems and technology transfer models, based on linear pipeline approaches, such as the technology supply push (TSP) approach (Hounkonnou et al. 2012). It is widely recognized that agricultural advisory services need to be re-conceptualized (Kilelu et al. 2014) as the complexity of knowledge production is better understood (Kingiri 2013). This requires a holistic approach and good understanding of how innovation works. Farmers have been forced to take a holistic

approach to their livelihoods throughout times, considering the implications of crop choice, diversification, investments etc. while being ready to adapt to any unforeseen changes or shocks. Their support system, agricultural research and extension, on the other hand, have gone through many different phases of development.

Klerkx et al. provide an informative account of the development of agricultural research from a single-discipline driven, *Diffusion of innovation* approach, through a *Farming Systems Research approach* to *Agricultural knowledge and information systems* (AKIS) and *Agricultural innovation systems* (AIS) (Klerkx et al. 2012). The traditional approach was very much focused on increasing production through technology transfer and by training farmers. Today farmers are seen as key partners in the process involved in the development of solutions. Extension activities are often focused on facilitating learning at all levels – from field to market (Asenso-Okyere et al. 2008).

This new approach to extension is largely based on innovation systems thinking. Innovations are new ideas and technologies that move from the ideation stage to actual integration into economic and social processes (Asenso-Okyere et al. 2008). An innovation systems approach sees innovation as a process, influenced by complex interactions between a number of actors and networks, with the goal to generate new knowledge, products and performance (Asenso-Okyere et al. 2008). There are different traditions in system's thinking, and no single definition of what a system is. However, since the 1960ies there has been general agreement that systems are characterized by complexity and uncertainty, while always being context specific (Schiere 2004). Hall and Clark talk about *complex adaptive systems*, where a system is defined as "an entity made up of interconnected elements" (Hall and Clark 2010, p.310). Each element, and the way it behaves, will affect the system as a whole. The system cannot be understood through analysis of individual parts. The dynamics and information flow between parts allow the innovation system to constantly evolve and change.

Looking at agricultural innovation from a systems perspective means highlighting the institutional or organizational contexts and the challenges they cause different users, rather than looking at individual technologies (Hounkonnou et al. 2016). This approach reaches far beyond technology and looks at innovations in society, in food systems, in markets, as part of natural resource management systems and at local ways of governing these (Pyburn 2014). It also focuses strongly on identifying the nuances of knowledge production processes (Shiferaw 2011, Hellin 2017). Klerkx et al. (2012) consider agriculutral innovation a co-evolutionary process, including ongoing change in the spheres of technology, society, economy and institutions. Factors such as "policy, legislation, infrastructure, funding and market development" (p. 458) also strongly influence the process. This is in line with the findings of Adjei-Nsiah et al. (2013) who have identified a number of institutional pre-requisites required for the innovation system to be effective and development to take place. They stress the importance of state driven enabling conditions, including infrastructure that supports market access, land ownerships issues as well as regulatory frameworks that support farmers. Putting pressure on state actors to improve the effectiveness of the extension system is therefore central.

Agricultural Innovation System (AIS) as an approach is still developing. It has developed in parallel with the Agricultural Knowledge and Information System (AKIS), with slightly different focus and methodology. The main difference between these two approaches is that AKIS has developed from an extension perspective with more focus put on the rural context, while AIS has developed from a research perspective. AIS takes a more holistic approach, studying also implications of institutional issues, such as the functionality of the markets and the policy environment (e.g. Hounkonnou et al. 2016). The main weakness of the AIS in comparison to the AKIS approach, identified by Klerkx et al., is the assumption of the AIS that there is a common goal which innovation is working towards. In reality an innovation process is always a multi-partner process involving several different stakeholder groups each representing their own perspectives, interests and ambitions, which may just as well be

competing as in line with each other (Madzudzo 2011, Klerkx et al. 2012). Strengthening and supporting the relationships within the networks is important as AIS does not automatically enhance interaction between actors. Local circumstances and institutional thinness may cause (mis)trust among the actors of the innovation system (Jauhiainen and Hooli 2017).

This illustrates the importance of strengthening the capacities both of individual agents to learn and innovate, as well as that of strong networks. Innovation capacity means having the capacity and processes in place to cope with shocks and change, both on individual and on a systems level (Hall and Clark 2010). Both institutional and non-institutional context specific factors influence innovation capacity (Noga et al 2017). On the one hand the system needs to focus on communication and interaction, knowledge-sharing and learning processes that support the strengthening of innovation capacity (Asenso-Okyere et al. 2008). On the other hand, efforts have to be made to build networks that pool capacity of different individuals and organisations, as few possess all the capabilities required. The dynamics between these actors will affect the functionality of the system (Spielman et al. 2009).

Positive community networks can build links across differences in social status, which could otherwise limit transfer of information and communication between stakeholders. This is one of the other challenges of the current extension system in many African countries. Often contact or model farmers have been chosen among active, well-off farmers. They seldom represent the poorest group of farmers, and may lack the links and networks to reach this most important target group (Noordin 2001).

3.5 Methods and tools in Agricultural Innovation Systems research

One of the main critiques of the Agricultural Innovation System framework is the limited methodological approaches available (Spielman et al. 2009). Also Hall and Clark (2010) acknowledge the

gap between the conceptual aspects of innovation processes and the actual policy relevant implementation methods or tools. Many studies from the field in Africa have simply been descriptions of the dynamics and process related to technological or institutional innovations (Spielman et al. 2009).

Spielman et al. discuss a few potential methods that could strengthen the AIS approach on a practical level to produce credible, comparable, policy-relevant outcomes. Suggestions include integrating statistical and econometric tools into studies doing systems or network analysis, or using experimental economics such as game theory (Spielman et al. 2009). This could potentially give more structured results even from individual case-studies, that bring out underlying patterns and trends from which lessons and policy could be up-scaled or generalized.

An innovation approach should put the farmers, their needs, wishes and capacity, in the centre of the innovation process. But often there is a mismatch between the actual needs of for example local farmers, and the support provided through extension (Kilelu et al. 2014). The innovation systems landscape in Africa does not support networking between these various actors and is not focused on strengthening knowledge adoption capacity (Madzudzo 2011). Farm-led innovation is still limited although farmers are often able to cope with major shocks affecting their food systems or livelihoods and would be the best source of information when developing new models or systems (Hall and Clark 2010).

The experimental games theory has been used in a few studies in rural Africa. Kebede and Zizzo compare the relationship between choices made in experimental games and actual outcomes of technological adoption[1] and find a strong negative correlation between

[1] In the case from Ethiopia the authors employ a so-called money burning game including a hypothetical lottery, after which the participants are given the chance to 'burn' other participants money, using their own hypothetical resources. The design is meant to show deeper motives of people in the community, e.g. how inequality aversion affects behavior (Kebede and Zizzo, 2015).

hostile behaviour in the games and regarding real-life agricultural innovations, suggesting that positive community networks are central for an enabling environment (Kebede and Zizzo 2015).

This is in line with previous studies. For example, Conley and Udry found social networks to be much more important than geographic proximity as a determinant for smallholder's willingness to learn and adopt new practices (Conley and Udry 2001).

This stresses the importance of involving local stakeholders as well as supporting local networks in the innovation processes. One tool to promote communication and network building is using an Innovation Platform, which will be discussed in the next section.

3.6 Innovation Platform as a participatory tool

Innovation Platforms (IP) have been increasingly used in different types of research and development projects in the past years (Pamuk et al. 2014). There is no single or established definition of an Innovation Platform or guidelines on how to run/support the IP process. But there is agreement that IPs should be tools to establish connections and networks between different stakeholders, allowing them to define the most relevant local problems as well as possible solutions together (Cadilhon 2013, Pham 2015). An IP should offer different stakeholders enabling conditions to engage in non-hierarchical processes to identify and solve local problems, initiate multi-stakeholder learning processes or explore changes that could be of common interest (Hounkonnou et al. 2012). It is a way to bridge the gap between the different interests and priorities of different actors, discussed previously.

IPs may be of a temporary nature with shifting configurations, but the key to their success is providing conditions and incentives for all members to participate in the innovation process (Adjei-Nsiah et al. 2013). The levels of action or intervention in which an IP can be established vary. Hounkonnou et al. (2016) differentiate between niches, regimes and landscapes. In theory an IP can be established to tackle issues at any of these levels. They suggest it is relatively

easy to generate change at niche level. It deals with specific issue, backed up by a shared vision, but can occur at any point in an institutional hierarchy. IPs can also be used by business partnerships as a tool to ignite innovation processes or business plans that create new business opportunities (Ngwenya and Hagman 2011). Whatever the specific context is, it is essential that the IP is participatory and it is considered to produce outcomes that are relevant and reliable enough to justify and motivate participation (Lilja and Dixon 2008). Also, institutional issues that need to be tackled and scaled up for lasting impact can be discussed by the IP (Adjei-Nsiah et al. 2013). It is therefore important to include also actors with the authority to influence policy and decision-making in the IP activity.

The lack of an official framework for the IP, however, means there is a lack of tools to measure the success and impact of IP-led activity. There are a few important studies that try to identify central aspects for the success of an IP (see Cadilhon 2013, Davies et al. 2016, Hounkonnou et al. 2016). The factors identified by these studies reveal the importance of structure and context, process, performance and conduct. Structure and context implies both the prerequisites of the external environment, but also the composition of the IP and characteristics of its members. Process and performance relate to the way that IP activities are linked to different levels of the value-chain, for example promoting market access or through capacity building. Conduct, finally, refers to the way in which IP members behave and communicate and the modalities for how meetings are conducted. Here issues such as trust and respect become central to the success of the IP. Also factors such as positive attitude towards change, entrepreneurial approach, as well as mobilizing resources and building market-links are pre-requisites for a well-functioning innovation system (Klerkx et al. 2012).

Finally, mainstreaming gender into the innovation process is central to sustainability and requires capacity building of both men and women, for example through guaranteeing representation of women in the IP. The experience of our case study (paper III) confirms many of the assumptions and views described here.

3.7 Empowerment

Another key concept of this thesis is *Empowerment,* central also within contemporary development discourse. Today empowerment is a broad concept defined in different ways by different individuals and scientists for particular contexts and purposes (Kumar and Quisumbing 2015). It first emerged in the 1970s in the field of social services, in relation to marginalised groups, referring to the principle that people should have the ability to act and participate in decision-making concerning their own well-being (Calvés 2009). The discourse was closely related to theories about power structures and distribution of power, recognising a bias against those with limited opportunities to influence the structures (Kabeer 2010). The concept was soon adopted by International Development discourse as a way to address issues of justice and human development. However, it gained a more formal status in development discourse through a push from the feminist movement in the Global South in the 1980s (Calvés 2009). They made the link between women empowerment and other development goals explicit (family well-being etc.), thus bringing it onto the political agenda.

The discourse in this field and the direction in development thinking has been significantly influenced by Nobel laureate Amartya Sen's Capability Approach (see e.g. Sen 1999, Sen 2009). Sen regards human capabilities as freedoms, rather than as a defined set of utilitarian 'human functionings' (Sen 2009). Sen's capability perspective is essentially based on freedoms to make life-choices that are individually valued as important. Different functionings carry different weights, both depending on individual preferences, but even more so on individual's pre-requisites. Issues such as age, gender, social roles, will significantly influence the capability of a person. But also issues such as health, disability and intra-household distribution will make for great individual disparities. The capability approach is therefore ultimately concerned with individual quality of life, or with the combinations of valued functionings that best support a person's freedoms to choose between alternative lives (Sen 1999).

However, not all people in all circumstance may have the capacity to choose their valued functionings. The capability set of an individual will always be shaped by society, community and family, and therefore there may be *potential capability* that can never be attained due to the lack of *opportunity capability* (Biggeri and Ferrannini 2014). Thus, choices made may reflect internalized values rather than actual freedoms (Kabeer 1999). For example, gender relations are a result of the values and practices in society, and reinforced through other social hierarchies including class and race (Agarwal 1997).

Also, poverty will significantly influence capability. Poverty is not only related to aspects such as finances or income (which is often used to measure poverty), but as much to socially constructed definitions of entitlement. Poverty is dynamic and follows processes of inclusion, exclusion and marginalization, which can cause social inequality and may exacerbate women's poverty (Kabeer 1997).

Feminists within the Global South movement, including Naila Kabeer, therefore argue that in addition to choice, various other concepts have important links to empowerment, including power, control, voice, awareness, and resources. Kabeer's (1999) definition of empowerment includes resources, as the pre-condition, agency the process and achievement the outcome. The central dimensions of most current definitions of empowerment include control over resources and ideology, and agency (Desai 2010). Resources include both physical resources, such as land, assets and funds, but also human and intellectual resources. Ideology refers to socio-cultural values, attitudes and religious beliefs of the community, as well as political and legal spheres of life (Charmes and Wieringa 2003). These are factors that influence the whole society and where change usually takes place at a slow pace.

In addition to these dimensions, Malhotra et al. (2002) in their definition, include also familial/interpersonal and psychological factors as central to empowerment. Agency refers to an individual's (or collective's) ability to take control and influence one's own life through choices made, as well as determining which choices are important (Desai 2010).

Many empowerment scholars view women's empowerment as a process, which involves moving to higher levels of opportunity to exercise power within central areas relating to awareness, choice, resources, voice, and participation (see e.g. Charmes and Wieringa 2003, Desai 2010). Malhotra et al. argue that there can be many different dimensions of empowerment, and being empowered in one dimension does not necessarily mean empowerment in another. Based on frameworks by several different authors Malhotra et al. define six central dimensions of importance to overall empowerment. These are economic, socio-cultural, familial/interpersonal, legal, political and psychological. Trommlerová et al. (2015) conclude that the most important determinants of empowerment are age, gender, marital status, nationality, economic activity, and health.

Gammage's et al. (2016) definition of empowerment focuses on the outcome of exercising agency, that is, the achievements in terms of improved welfare and well-being. They consider the key aspects of empowerment to be 'how women's relationships with men influence their access and control of resources as well as their agency' (p.224) and identify several central aspects of empowerment critical for food and nutrition security. They find clear evidence that the food security status of the household improves when the primary female has a 'sense of economic agency' as well as a higher level of 'physical capital empowerment' (Sharaunga et al. 2016). When women have a higher sense of agency they have a better capacity to identify goals, as well as a better capability to act towards these goals.

Another field of empowerment research studies the position of women in the household specifically in relation to women's health issues, such as the use of contraceptives (for example Khan et al. 2011, Dito 2015) or on the relationships between women empowerment and child nutrition (review of the literature by Cunningham et al. 2014). A strong link has been found between women's greater share of power in the household and participation in financial management and household food security and health spending (Sharaunga et al. 2016, Wouterse 2016).

In this context also understanding intra-household power relations and dynamics is important, as they tend to both reflect and contribute to the wider institutional environment. This in turn influences the normative and allocative activities of the state, which may lead to "gender differentiated structures of opportunity" (Kabeer 1997 p.6). Many feminists therefore argue that a radical transformation of the economic, political, legal, and social structures that perpetuate gender, race, and class dominations, needs to take place (Calvés 2009).

Although these studies focus on different aspects of empowerment, they all argue the importance of empowerment in relation to wellbeing. Thus, they become a human rights concern, and therefore central to any development discourse. The specific aspect of empowerment adopted by this study is linked to women's decision-making, agricultural production and the use of income.

3.8 Measuring Empowerment

From the above discussion it becomes evident that empowerment as a concept is extremely important from a development point of view. The lack of a single definition, however, makes measuring empowerment challenging. Factors relating to empowerment are often difficult to conceptualize at a practical, measurable level, making it challenging to define useful indicators. Proxies have often been used, such as employment or education. However, these can be considered enabling factors or catalysts for empowerment, rather than empowerment per se (Malhotra et al. 2002, Kishor and Subaiya 2005). This is in line with Sen's capability approach, which also considers for example income to have instrumental value, rather than intrinsic importance (Sen 1999). The fact that empowerment is often seen as a process involving change, also sets challenges for measurements. Many issues tend to evolve and change over time in any case, and issues that may once have been considered empowering may change to normative (one example is the use of contraceptives). Also, measurements therefore have to be adapted over time.

Information about women's empowerment has been integrated into most demographic and health surveys, conducted routinely every few years in most of the world's nations. But they also have limitations, which are important to understand. They may not reflect the realities of all groups in society, as there may be significant differences for example between women belonging to different socioeconomic or ethnic groups (Heckert and Fabic 2013), or important sub-national and regional disparities (OECD 2015).

In 1995 the UNDP Human Development Report (HDR) for the first time included measurements on women empowerment. These included the gender-related development index (GDI), concentrating on inequality between men and women in relation to the basic indicators of human development, such as access to basic resources, longevity, and education. The second index included in the report was the Gender Empowerment Index (GEM), which includes three variables related to women's participation in political decision-making, access to professional opportunities and earning power (UNDP 1995). Many key aspects of empowerment are missing from this index, as also recognized by the developers themselves, due to the challenges of data collection. This includes factors such as women participation in community and household decision-making and use of resources.

Integrating a gender component into the HDR was however an important step as it highlighted the importance of the gap between men's and women's capabilities and opportunities (UNDP 2015). Also other actors started developing a multitude of different gender empowerment and inequality measurements (UNDP 2015). Many of these are constructed to calculate ratios of women to men in different arenas of life, such as education, access to work, power, decision-making, time-use and health. An important function of these measurements is that they can be used to raise awareness, planning and policy analysis (Charmes and Wieringa 2003) or as mechanisms to monitor gender equality and women's advancement (ECA 2011).

Even so, one of the large gaps in improving the understanding of empowerment related issues is still the lack of relevant data, as

previously discussed. Policies in Sub-Saharan Africa (SSA) often rely on Demographic and Health Surveys (DHSs), which still have limitations when it comes to women's empowerment issues. The traditional way of looking at the household is as a single unit, measuring output and wellbeing based on common or joint figures. However, it has become evident through research that this does not accurately reflect the realities of the individuals within the household (Udri et al. 1995). For example, the large group of women farmers living and working as part of male headed households may have very different pre-requisites, access and opportunities, compared to their male counterparts (Doss 2013, Doss 2014). Therefore there has been a strong push towards collecting sex-disaggregated data, in order to allow inference on individual level. Heckert and Fabic (2013) try to identify the gaps in the existing surveys and find ways in which the questions could be improved to better reflect women's empowerment in SSA. They conclude that additional measurements of empowerment regarding economic issues, such as access to inputs including land and capital, would be critical in order to get a holistic picture of the limitations women face in developing their economic autonomy and empowerment. To access robust and relevant gender data requires more nuanced, specific and continued data collection efforts. (Peterman et al. 2011, Combaz 2013, Doss 2013)

For more specific information, many studies use vectors consisting of individual variables relevant for empowerment, such as years of education, employment status, age, number of children, and socio-economics status (Khan et al. 2011). Another approach is using indexes to capture the different dimensions of empowerment. The most useful measures need to be defined based on the particular objectives and context in question, and specific methodologies for collecting the relevant data needs to be developed.

The Women Empowerment in Agriculture index (WEAI), discussed below, is one example of a sector-specific measurement of empowerment, targeting women's empowerment within the agricultural sector.

3.9 Women Empowerment in Agriculture Index

The Women Empowerment in Agriculture Index (WEAI) was developed in 2011-12 by International Food Policy Research Institute (IFPRI) and Oxford Poverty and Human Development Initiative (OPHI) as a monitoring and evaluation tool of USAID's Feed the Future programme (Alkire et al. 2013). The aim was to use the WEAI to measure the impact on women's empowerment that the activities of Feed the Future projects contributed. It is an index based on a multi-dimensional poverty approach (Alkire and Foster 2007) that measures women's empowerment in five domains central for agriculture. The domains are production, resources, income, leadership and time, split into ten sub-categories given different weight. The questions about production and income concern the self-reported participation in decision-making regarding production of food crops, cash-crops, livestock, and on use of income from each of these activities. The resource domain concerns ownership, access and decision-making regarding land, livestock, equipment, durables, and credit. The leadership domain focuses on participation in community groups and possibility to actively express ones opinion regarding local concerns. Finally, the time domain measures time allocated to different key activities, including work, sleep, household chores and leisure time, based on a 24-hour recall survey (Alkire et al. 2013).

Empowerment can be measured separately for each individual domain. A specific empowerment cut-off is defined for each, and together they make up the overall empowerment score of an individual. In addition, a gender parity score is calculated, which compares the score of the male and female respondent (usually spouses) in each household. More detailed information about the WEAI can be found in paper I, which uses an adapted version of the WEAI to identify links between empowerment and particular household characteristics.

As the developers of the index themselves say, one of the most important contributions of the WEAI is to raise awareness relating to gender, empowerment and equality, and the type of issues or interventions that may influence these (Meinzen-Dick 2013). Gender-

blind projects, while they may have good intentions, can even lead to negative outcomes for women. Even though there are many important aspects of empowerment left out of the index that will also greatly influence women's lives, the WEAI is still a good diagnostic tool for identifying the most important areas affecting inequality and disempowerment among both male and female farmers. This understanding can provide important contributions towards targeted policy recommendations.

3.10 Productivity and Efficiency

Productivity of smallholder famers in Africa is generally low. No country, apart from South Africa, achieves even 25 per cent of its productive potential (Ali et al. 2016). There is thus room for significant improvement. The reasons for the low productivity are manifold, as discussed previously, and the same is true for the possible solutions. They will depend both on the context and the objective of the study or project. In order to develop solutions, the determinants of the low productivity need to be identified and analysed. In concrete terms productivity measures the amount of input produced using a certain amount of inputs.

There are a number of studies on difference in productivity between men and women, but the findings are not conclusive. A traditional production function approach assumes that men and women produce the same output using the same technology. They often find women to be less productive (see e.g. Quisumbing 1996). The approach can, however, be seen as conceptually and methodologically problematic. Many studies have for example attributed women's lower productivity to lower levels of human and physical capital, ignoring the array of factors that can lie behind and contribute to these differences. Such an approach is not particularly helpful, when attempting to identify policy implications and recommendations for improving women's productivity.

Defining a useful approach is therefore important. One key aspect of productivity which can be informative and useful to look at is technical efficiency. Technical efficiency is a measure that compares the

amount produced, in relation to what potentially would be possible with the same amount of input. In the context of this thesis efficiency is used strictly as a technical tool that can provide insight into resource use. Although there may be various culture-specific notions relating both to productivity and efficiency, the approach here is to consider impacts on natural resources and sustainability. The inputs normally included in an efficiency model are seed, fertilizers, pesticides, and labour. The analysis usually continues to look at the determinants of efficiency, that is, the factors that affect efficiency either positively or negatively (Coelli et al. 2002).

Studies of efficiency commonly lean on the theories of productive efficiency introduced by Farrell in 1957 (Farrell 1957). But efficiency can be studied from several different viewpoints, providing insights into different aspects of efficiency, most commonly technical, allocative and economic efficiency. For example, allocative efficiency can give important information on intra-household distribution and other gender-specific constraints (Quisumbing 1996).

As different models measure slightly different aspects of efficiency, also the results will differ (Tchale 2009). For example, Tchale's study from Malawi gives different estimates for mean efficiency of the same group, depending on the focus. Mean technical efficiency was 53 percent, allocative efficiency 46 percent, while the economic efficiency was only 38 percent. Although the results vary, they all point in the same direction - that smallholder productivity could be doubled even with current inputs and technology, if efficiency was improved. Since Quisumbing's important review article in 1996 many studies have attempted to identify underlying reasons for the differences in productivity and efficiency. But many of the studies still ignore issues such as women's human and physical capital, or women's educational disadvantage, although they are central to efficiency (Quisumbing 1996, Coelli et al. 2002). Even behind characteristics such as physical size or strength, culturally constructed facts can be identified, such as differences in nutritional allocation between girl and boy children (Peterman et al. 2011). Many other socioeconomic characteristics, as predictors of technical efficiency, also need to be considered for a model to be useful (Rahman 2010). However, also in this

field the lack of gender disaggregated data has inhibited the development of truly useful studies. Good data collection and selecting relevant indicators is therefore essential in order to make useful reflections not only on the direct causes, but also the underlying reasons for the efficiency gap.

In addition, any results will be context specific, which has implications for their generalizability (Peterman et al. 2011). No too far-reaching assumptions can be drawn based on a single study. But on the other hand, also individual studies can point to underlying patterns that are found in many contexts. These patterns can illuminate key issues that influence economic realities and relationships on the micro level as well as changing processes on a macro level and can thus contribute to the overall understanding of the key issues and challenges to focus on.

3.11 Stochastic Frontier Analysis

The method for measuring technical efficiency that has dominated in the past couple of decades is the stochastic frontier approach, based on work by Aigner, Lovell and Schmidt as well as Meeusen and Van Den Broeck, both from 1977 (Aigner et al. 1977, Battese and Coelli 1995, Kumbhakar and Lovell 2000). It is a useful tool as it allows identification of the inefficiency term, that is, the variables that together or individually contribute to inefficiency.

Stochastic frontier models rely on one of the production functions, most commonly Cobb-Douglas, quadratic or the translog function. Both are linear in parameters and can be estimated using least squares methods that allow multi-output and multi-input distance functions. The disadvantage of the Cobb-Douglas function is its simplicity, assuming similar elasticities of production for all firms (or farms). The quadratic and translog functions are flexible functional forms providing a second order approximation (Anang et al. 2016). Choosing the right model should be based on the data and on the best fit, as different models may give slightly different results (Kuosmanen et al. 2013). Using a Log-likelihood ratio test, allows

comparison between models, to identify the most appropriate one (Battese and Coelli 1995).

SFA identifies specific variables to explain efficiency, for example family size, number of working adults in the household, education or experience of family members, size of cultivated land and land quality, land tenancy, share of household income from off-farm activity, frequency of extension contact, to name a few. There is, however, no formal econometric model of technical efficiency (Battese and Coelli 1995, Battese et al. 1996). This lack of a single or comprehensive definition of inefficiency means there is always a degree of arbitrariness in the choice of inefficiency variables (Irz and Thirtle 2004). It is up to each scientist to make an informed choice on which variables are relevant for the specific research question, the available data and the focus of the study.

When developing the stochastic frontier model for a given case, the perspective from which efficiency is studied therefore needs to be defined. The focus can be either on how input can be minimized while still achieving the same amount of output (output oriented), or on how output can be maximized with the given inputs (input oriented). It will depend both on the data at hand and on the focus of the study. For example, Rahman chooses an input-oriented stochastic distance function for his study from Bangladesh. The prime concern of Bangladeshi farmers is cost minimization as inputs, including land, are scarce, while farmers are cash constrained (Rahman 2010). In another study from Bangladesh, Coelli et al. (2002) find that farmers could reduce costs up to 20% through better allocative efficiency. However, Coelli et al. note that overuse of labour may be evidence of disguised unemployment, rather than an actual allocative choice of the household, and therefore it may not be easy to improve allocative efficiency. Depending on the focus of the study also an output-oriented approach can be meaningful, for example if the aim is to determine how output could be increased through a more efficient use of the current sources of input.

Using this type of econometric modelling can give a good insight into structures and patterns and how they influence efficiency and

productivity of different groups. This is central to identifying the most pressing policy relevant issues. However, as we found in most of the studies mentioned above, context plays a significant role and will have major impact on any given case.

3.12 Sustainability science and sustainability transition

Sustainability discourse still commonly refers back to the definition of the Brundtland commission from the 1980ies, defining as its goal to sustain nature, life support systems and communities (WCED 1987, Kates et al. 2005). Actions to promote sustainable development are defined through goals, for which a number of different indicator sets have been developed, as well as through values and practices. Both definitions and approaches have developed over the years, but the basics are still the same and the challenges remain. In the 2000s sustainability science emerged as a new scientific discipline, aiming at finding ways towards a sustainable society. It recognises the complexity of sustainability problems and adopts a comprehensive, holistic approach to the roles played by global, social and human systems, as well as their interactions (Komiyama and Takeuchi, 2006). Sustainability science requires a transdisciplinary framework linking knowledge and solutions from individual disciplines, that can be taken from a phenomenological level towards practical and applied research questions. A key methodological appraoch is using co-creation or co-production of knowledge, stemming from the field of science and technology studies (Jasanoff 2006).

The concept of sustainability in the context of this study is understood to include sustainability of natural systems, including agricultural and ecological systems. But it also entails social and economic sustainability, which implies that the new farming systems and livelihood strategies developed should be socially viable. While supporting food security and wellbeing of people, they should also support equality and development. Sustainability also puts pressure on the types of productivity and efficiency growth envisioned. It requires all growth to take sustainable forms, that is, it promotes farming

practices, technology and innovation that are climate friendly and sustainable.

A central question then becomes whether a conflict exists between human development in and African context, and environmental sustainability? Eskonheimo (2006) discusses this at length in her PhD thesis and finds that there are ways to bridge this gap. She argues that people may have "a plurality of positions towards their environment" (2006, p. 27), and suggest that collective management of natural resources and co-creation of practices are central for sustainability.

From this background it is meaningful to discuss how transformations of systems take place and the role that different actors have in these processes. Shot and Kanger (2018), in a recent paper talk about systematic global change processes or 'Deep Transitions'. Their theoretical and scientific approach is closely linked to the field of Sustainability science. It looks at the fundamental interconnections between different socio-technical systems as well as the dynamics leading to social, economic and ecological changes, including the actors that drive them. Deep transition processes can emerge, when a number of initiatives and niche innovations start taking place. Currently there are a number of niche innovations emerging that may contribute towards a transition, including the ICT revolution, green growth, institutional innovations and enabling policy. However, there will have to be a strong enough push-pull effect in order to 'tilt the playing field' and turn these niches into a new regime (Shot and Kanger 2018). The main insight is that processes, or surges, always happen in parallel within different niches emerging due to different local and global landscape pressures. Different opportunities create new socio-technical systems and associated rules. These processes are always influenced by a number of different actors and stakeholder, from social movements, to private sector, to government. The agency of the various actors is crucial in shaping the process (Shot and Kanger 2018). In the context of this thesis, these insights are very interesting. The pathways identified in this work can been considered niche innovations.

4 Conceptual Framework

The above summary of scientific approaches and methodologies relevant for the research questions of this thesis provide a platform on which a wider theoretical discussion can be built, to illuminate the general contribution of this work. The way the concepts have been utilised and interpreted in this context, provides the basis for the conceptual framework.

The conceptual framework has been developed drawing on the above theories, while recognising the multidisciplinary nature of the work of this thesis. It is largely driven by the empirical work done in the three studies. They provide the opportunity to analyse both qualitative and quantitative data, using an exploratory content-driven orientation (Guest et al. 2012). Figure 1 aims to capture the key elements and concepts relating closely to the study, as well as some of their inter-linkages. The scientific home of this study is in Agricultural Science, or more specifically in Agricultural Economics. However, the approach used falls under AIS. This approach has strong links to Sustainability Science, as introduced by Komiyama and Takeuchi (2006). The discourse on agency and empowerment, taken from their sociological roots towards an applied aspect of agricultural science, also plays a vital role in the conceptual framework.

Although there is a pallet of methodologies that can be used within these fields, a common feature in most of them is using a trans-disciplinary or mixed-method approach. This means an issue is always studied from several different starting points, using a number of scientific methods. Another key aspect of both the AIS and the sustainability science approach, is involving a range of different stakeholders as central actors of the research process. Therefore also the methods and tools used here have a highly participatory nature. The conceptual framework organises the tools to analyse the cases in the field. However, also the feedback from the field influences the development of the framework itself. Constructing a conceptual framework for this type of study can therefore in itself be seen as a process (Eskonheimo 2006).

This thesis, and its conceptual framework is therefore not built on one specific theory or theoretical approach, but is considered a process. It starts by visualising the interlinkages between the key scientific fields, described in figure 1, but is developed and updated through the research process and the contributions made through the actual case studies. In figure 2, referred to as the results framework, the outcome of this process and the lessons learned are depicted as pathways. They each have the potential to contribute towards sustainability in their own way. The most important goal of the process is precisely that; to identify and develop the most relevant pathways in order to make the best contribution towards sustainability. The orientation of the overall study is therefore of an inductive nature, taking a primarily exploratory approach, integrating lessons learned from the process to identify these pathways. In the text below, the key conceptual factors, their roles and linkages are

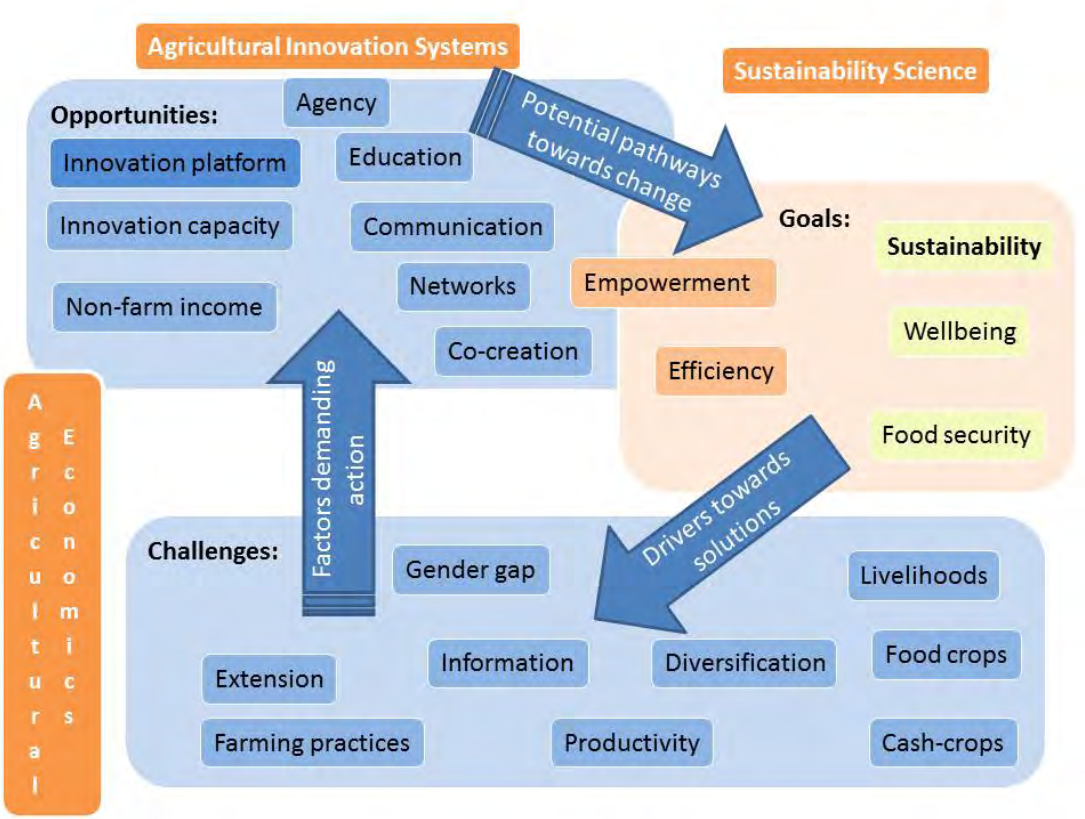

Figure 1. Conceptual framework

described in more detail than what is reflected in the simple graph. The results section discusses the outcomes, and the pathways developed based on them, as visualised in the results framework (Figure 2).

The above figure is a graphic visualisation of the thematically important concepts within the scientific areas relevant for the work in this thesis. It depicts them as factors influencing the overarching theoretical framework. They each affect the dynamics of the system and are interlinked in a number of ways (differently in different contexts and at different points in time). The concepts included in the 'challenges' box represent issues that in many cases cause challenges for small-scale farmers. Thereby they constitute factors demanding action, at different levels and by different actors. They can ignite and activate the opportunities contributing to change. Many of them can, however, also be part of the solutions, if supported and developed in the most suitable ways. The 'Opportunities' reflect the possible solutions as well as other issues that provide promising contributions to potential pathways towards new opportunities and change. 'Goals' are the previously mentioned overall goals of sustainability, wellbeing and food security, but also goals relating to empowerment and efficiency. The goals can have an important function as drivers of change, contributing towards finding sustainable solutions. Both empowerment and efficiency are considered goals in themselves, but are here also seen part of the opportunities and solutions.

Each of the three papers covers particular aspects of the conceptual framework, but all try to tackle some of the specific challenges of the agricultural system. In addition to the gender gap, the main challenges studied here include the lack of useful information and extension support for farmers to improve their farming practices and increase their productivity.

Using a more traditional Agricultural Economics approach and methodology, described in more detail in the methodology section below, the first two papers analyse quantitative household data. The first paper focuses on the link between empowerment and a range of farm household characteristics and farming practices. From an

Agricultural Economics point of view, the interesting questions lie in studying the different aspects of the farming system. The choices made by the households and the implications these choices have for productivity as well as for empowerment are key factors. There are many endogenous issues involved that affect the productivity and efficiency of the household or its members, including crop choice, farming practices, input use, diversification and market strategies. These will all have implications for livelihoods, food security and overall well-being of all household members. Using econometric models based on production functions can help to understand some of the dynamics behind these processes.

The second paper is very much linked to sustainability through its focus on efficiency, that is, how well inputs are allocated towards producing the most optimal output. From a sustainability point of view this is a key goal as resources should not be wasted. The paper tries to capture the most important factors that influence efficiency, in order to find ways to improve it. The farming systems and practices chosen by a farming household will significantly influence efficiency. This includes household decisions made relating to resource use and resource distribution as well as choice of crops, diversification and participation in non-farm income generating activity. Another important factor influencing efficiency is an understanding of the available options and capacity of the farmers to make informed choices. The role of extension, education and human capacity is a central part of this.

The third paper, using an agricultural systems approach, focuses specifically on the capacity of farmers and other key stakeholders to innovate as part of developing and improving their farming practices and productivity. Empowerment plays a key role, as both empowerment and education will positively influence people's innovation capacity. Community networks and a range of different communication channels can also influence these processes.

With this discussion and the concepts included in the conceptual framework in mind, I return to the overall research questions of this thesis and discuss briefly how they fit into the framework.

1. What are the key aspects or characteristics of women empowerment among small-scale farmers?
2. How do these characteristics relate to the productivity and efficiency of farming practices of men and women?
3. How can participation in the innovation processes support small-scale farmers', particularly women farmers', empowerment, productivity and visions for the future?
4. How can these approaches be used to develop pathways towards sustainability?

In order to identify the characteristics of women empowerment among small-scale farmers (question 1), issues relating both to the individual features of the women in the households as well as the farming practices need to be studied more closely. This will also give some indication towards the issues that support or inhibit women farmers' efficiency. Empowerment is strongly linked to issues such as agency, but also to different forms of learning or participatory learning experiences. As innovation systems support learning through participation in innovation processes, Innovation Platforms may be suitable tools or pathway to address issues related to empowerment.

There is a variety of farming systems in rural Africa, many of which build on a long history of traditional practices. There is a great potential in indigenous knowledge, which in many cases can be an untapped resource, for example positively affecting nutrition (Lachat et al. 2017). In many cases, however, the practices may no longer be enough to sustain local communities, due to growing populations and degradation of soils and depletion of biodiversity (Getnet et al. 2017). A variety of factors affect both productivity and sustainability of farming practices, including environmental and climatic factors, but also socio-political ones. The role of women farmers, and how they play into the overall framework, is a central question. Women farmers have an important role as producers of a large share of the locally consumed food and thus their potential influence on food security is significant (Combaz 2013). Therefore, also the specific factors influencing their productivity and efficiency are important to understand (question 2). From an agricultural innovation systems perspective it

can be assumed that factors and characteristics of farm households where women are empowered may also be linked to questions of productivity and making decisions that promote household wellbeing (Malhotra et al. 2002).

The functionality of the local extension system is a factor that can greatly affect the performance of farmers. Is it able to reach all farmers, even the remote and uneducated ones, and does its messages convey information to farmers in an optimal and useful way that is easy to put into practice? There have been attempts to improve the sector in the past years, especially in Ethiopia, but much still remains to be done in order to support farmers in the most beneficial ways (Krishnan and Patnam 2013). Changing farming practices is a slow process, but studies have shown that if farmers themselves are involved in innovating new technologies and practices, the potential for change – especially sustainable change – is much higher (see background chapter 3). An Innovation Platform provides opportunities for this type of engagement and participation (Hounkonnou et al. 2016, Davies et al. 2016). When farmers themselves, also the most marginalised small-scale women farmers, have a chance to participate it is likely that their experience of empowerment and opportunity increases (question 3) (Davies et al. 2016). Therefore, supporting the extension system to find new models and participatory tools is an important developmental goal.

The farming practices, in turn, influence a range of issues central for household wellbeing. Choices made by the households for example regarding diversification will influence the types of income generating activities available to household members. Also, a range of other factors will influence the effectiveness and productivity of the household. All of these factors will have implications for livelihood opportunities, food security and household wellbeing, and will be central to understand in order to develop new pathways in response to research question four.

5 Uganda and Ethiopia

Before describing the empirical studies included in this thesis it is in order to provide some relevant background information on the two countries in which the empirical work has taken place, namely Uganda and Ethiopia.

Uganda is one of the countries in East Africa which has had a relatively stable development and positive economic growth leading to poverty reduction in the past decades (Mukwaya et al. 2011, UBOS 2014, De la o Campos 2016). However, Uganda is still a low income country with a predominantly rural population. Only 15 percent live in urban areas, and 72 percent of the approximately 34.9 million inhabitants are involved in agriculture (UBOS 2014). Considering its important role for the population, the fact that agriculture still contributes only 21 percent of the country's GDP, suggests that it is not as efficient as it could be. In addition, the growth in the sector has stalled in the past years and is now down to 2.2 percent, in relation to a population growth of 3.2 percent (Ali et al. 2016). In terms of future food security and wellbeing of the population this is a worrying trend. Increases in crop production in the past years were due mostly to expansion of cropland, rather than improved yields on current cropland (Mukwaya et al. 2011). A reason for this is the fact that the majority of farmers are poor subsistence farmers, faced with many constraints, including lack of access to inputs (FOWODE 2012, De la o Campos 2016).

Another feature of Ugandan agriculture, which may affect future productivity, is the recent trend towards feminisation of agriculture (Doss 2014). Over 70 percent of all women and 90 percent of rural women work in agriculture, compared to only 53 percent of rural men (FOWODE 2012, Ali et al. 2016). Attitudes toward agriculture have changed as earnings and profitability has gone down, which has led to men and boys migrating to urban areas in search of alternative opportunities (FOWODE 2012). However, men on average still have larger plots than women (Ali et al. 2016) and are more likely to focus on cash-crop production, such as coffee (own survey data). In

addition to the most important cash-crop coffee, the most common crops grown by small-holder farmers in Uganda are the local staple food *matooke* (plantain), roots and tubers for home consumption and grains, beans, maize and groundnuts both for sale and for household consumption (Peterman et al. 2011). Although no crops can be directly classified as women's crops, for example Ali et al. (2016) find that women are significantly more likely to grow a larger share of roots, pulses and oilseeds, while men are more likely to be involved in cultivation of cereals, bananas and cash-cops. Improved seed are used only by 25 percent of male farmers and 20 percent of females (in 2003) (FOWODE 2012). Over eighty percent of the seed used in Uganda comes from the informal sector (Mubangizi 2012), which may cause issues relating to quality and reliability.

Despite low yields of many crops, however, agricultural potential in Uganda is described to be high, given the country's agro-ecological diversity (De la o Campos, 2016). There are seven different agro-ecological zones in Uganda, representing different altitude and soil types. Although the climate varies in these zones, two rainy seasons dominate Ugandan agriculture – the main planting season between March and June, and the light rains between October and January (Hisali et al. 2011). The soil types of the productive agricultural land range from areas of low to moderate productivity to very high productivity. The majority of Ugandan agriculture is rain fed and therefore also rainfall patterns highly affect productivity. The changes in rainfall patterns due to climate change and the effects this will have on agriculture, is difficult to predict accurately. Most studies expect rainfall in Uganda to increase, which may be beneficial for agriculutre (Kikoyo and Norbert 2016). However, different types of climate shocks are also expected, which suggests adaptation measures will be critical. Currently household resilience is low and adaptation strategies insufficient (Hisali et al. 2011). To tackle this, a combination of policy measures, investments and capacity building will be necessary.

One factor inhibiting investment in adaptation measures and improved technologies is insecure land rights. According to Hisali et al. (2011) secure land tenure arrangements increases the likelihood to adopt climate smart technology. This is an important finding, as the

tenure system in Uganda in practice still largely favours men (FOWODE 2012, Combaz 2013, De la o Campos 2016). Women headed households in Uganda hold less than half of the land size compared to that owned by male headed households (FOWODE 2012) and also within male headed households, women tend to have a very small percentage of the official land documents. That said, it is also important to consider the different kinds of ownership, including statutory versus customary (Doss et al. 2014), and actual documented ownership versus reported or de facto ownership. In practice de facto ownership may be more important in terms of decision making (Doss et al. 2013). Women also cultivate significantly smaller areas of land (Hill and Vigneri 2009) and are more likely to grow food-crops for home consumption, while men tend to grow cash-crops. It is difficult for women to overcome the barriers related to market-oriented agriculture. One barrier is accessing credit, again an issue closely related to land-ownership, as land deeds are often required as collateral (FOWODE 2012). Women farmers in Uganda also face a number of other gender-specific constraints, including limited access to information and extension, but also time constraints, as they usually carry the brunt of the household work load (Combaz 2013). Women tend to have less flexibility with respect to non-farm income generating activities, such as employment (Stats from UBOS). The reasons for this can be attributed both to the time constraints mentioned, but also to a discriminating labour market as well as a range of other socio-cultural factors.

Ethiopia is another East African country the economy of which has grown remarkably in the past decade, leading to great improvements in terms of poverty reduction (World Bank 2015). One of the differences compared to Uganda, however, is the massive population. Ethiopia is the second largest country in Africa with its close to 100 million inhabitants. It is characterised by great religious and ethnic diversity, including more than 85 different ethnic groups (Kumar and Quisumbing 2015). Out of the population nearly half (47%) is under the age of 15, according to the Central Statistical Agency (CSA) of Ethiopia (CSA 2016). The average household size varies slightly depending on what statistical information is used. According to CSA it is 4.6

members, and women have on average 4.6 children (a decline of 0.9 since 2000) but the socio-economic status of families influence these numbers significantly. Among the poorest households the average number of children is 6.4, while for the richest it is 2.6 (CSA). According to the Ethiopia Socioeconomic Survey (ESS) implemented in collaboration with the World Bank Living Standard Measurement Study (LSMS) for 2015/16 average household size is 4.8 persons overall and 5.2 in rural areas (LSMS 2017). Nearly half (48%) of the women in Ethiopia still have no education, compared to 28 percent of men.

Also, in terms of climatic conditions the variation within Ethiopia is substantial, with a great number of different agro-ecological zones (the number of zones varies depending on the way they are calculated for different purposes, see e.g. Hurni 1998) providing very different premises for farming. Agriculture plays an even more important role in Ethiopia compared to Uganda, with 80% of the population employed within the agricultural sector, producing 41% of the country's GDP (LSMS 2017). In rural areas 98 percent of households are involved in agriculture, compared to 64 percent of households in smaller towns. The average size of land holding owned by the households is 1.4 hectares, although this varies depending on region and household type. For example, female headed households tend to have smaller land holdings (LSMS 2017). The majority (60-80 percent) of crops farmed are consumed by the family. Only 8-21 percent of the produce is sold, mostly high value crops such as teff and wheat (LSMS 2017). Having some form of livestock is very common among rural households, indigenous breed cattle being the most important.

The most important local staple foods are cereals (particularly rice, wheat, sorghum and barley), consumed regularly by 90 percent of households. People living in towns consume a more diverse diet than those in rural areas (LSMS 2017). Food security is still a great challenge for Ethiopia. Twenty-six percent of households reported food shortages, or so-called lean periods, at least once in the past twelve months (LSMS 2017).

The Ethiopian government has recognised the challenge of feeding he population and made major investments and improvement in the

national agricultural extension program since the early 2000s (Krishnan and Patnam 2013). Throught the Agricultural Transformation Agency (ATA) a number of new initiatives and local structures have been implemented to support small-scale farmer technology uptake and linking them to markets. A so called 5 to 1 methodology has been developed in which all farmers are grouped into smaller units, each individual belonging to a 5-1 group. One member takes on the role of model farmer, while the others are meant to observe and learn from this farmer. No official evaluation of the initiative has been completed, but according to Krishnan and Patnam (2013) the results have been mixed.

In addition to the official extension programs, however, there are many other networks that link people in the community. Local networks play a key role in informing Ethiopian farmers on agricultural practices. Improving the official extension services has been a focus of government interventions in the past years. In some cases neighbours can in fact be more effective in supporting adoption of new technologies than the official channels (Krishnan & Patnam 2013). The coffee ceremony has a very central role in Ethiopian society, and is an important forum for information and knowledge exchange. People tend to belong to coffee ceremony groups both based on proximity and on kinship. Both men and women from the households are usually involved in the ceremonies (interview data). Also, the religious groups to which people belong constitute additional important information sharing fora.

Ethiopia is also faced with the challenge climate change is expected to cause agricultural productivity and food security (Rimhanen 2016). These challenges will be exacerbated by Ethiopia's degraded ecosystems, caused by soil erosion and nutrient depletion. Just as in Uganda inputs such as fertilizers are used much below the recommended level (Getnet et al. 2017). For the most imporant cash-crops; maize, wheat, barley and teff, fertiliers are used on approximately two thirds of plots. For other crops it is much less common (LSMS 2017). Use of improved seed is only common for maize and wheat, overall more than 81 percent of grain plots are planted with traiditional seed (LSMS 2017).

6 Data and Methods

This thesis includes three empirical studies, each providing input into a specific aspect of the conceptual framework described above. Each study uses a specific approach to illuminate the relevance of the question for the overall challenge. Two of the analysis are based on data from a quantitative household survey in Uganda, the third on a qualitative participatory research study from Ethiopia. Although tackling similar overall issues, each has its own research questions, as described below. The different methods each have their own strengths and weaknesses, but together provide a good understanding of both the key challenges and opportunities. Econometric models using survey data provide insight into the patterns of women's roles and participation in the agricultural sector. A qualitative case study, on the other hand, can give more in-depth understanding of the underlying dynamics in the community driving and reinforcing these patterns, but also identify where the opportunities for change and innovation lie.

Papers I and II both utilize a large dataset collected in Uganda for the Finnish funded FoodAfrica Programme in late 2012 and early 2013. Detailed household and agricultural data were collected from approximately 1440 farm households in eight regions of Uganda. The data included information on household members (age, education, primary and secondary activity), household asset ownership, farming systems (details on crops and inputs) and marketing patters. The primary use of the data was a randomised control trial (RCT) led by International Food Policy Research Institute (IFPRI), to analyse the effect of market and extension information sent by text message, on farmers' income. This required a number of basic facts and information.

The survey data provide a good overview of the realities of Ugandan small-scale farmers. The households included in the study represent small-scale farmers, producing crops as their main form of income. Eighteen percent of the households were female-headed. Most of the households were involved in mixed farming, growing both food crops

and cash crops. In fact, it was difficult to clearly distinguish between food and cash-crops in the Ugandan context, as most farmers grew crops, such as matoke and maize, both for home consumption and for sale. The most commonly grown crops were maize, matoke (cooking banana), beans and coffee. Coffee is the main cash-crop in Uganda and also among the survey households. There were no crops grown exclusively by men or women, but beans were commonly grown by women (and could be considered a women's crop), while it was much more common for men to grow coffee than for women (survey data).

The households in general owned very few assets and only 7.6 per cent had access to electricity. Based on the data we find that food security is a serious problem in Uganda. Forty-nine per cent of households reported having experienced at least one hungry period during the past twelve months. Some regional differences regarding food security were found, which may at least in part be due to differences in agro-ecological zones and population density. Further studies would be needed to get more detailed information about these differences.

Paper I: What factors explain women's empowerment? Decision-making among small-scale farmers in Uganda.

The aim of the study was to identify household characteristics associated with women's empowerment. This included community and household level characteristics as well as individual characteristics of household members. The assumption behind the study was that there are certain household characteristics or features that are correlated with empowerment and that identifying these will provide science-based evidence for policy-makers. This can entail local government policy on for example schooling or extension schemes.

Our study is inspired by the Women Empowerment in Agriculture Index (WEAI). We have not used the index in full, but adapted parts of it for our purposes. One of the key aspects of the index we have integrated into our study is looking not only at female headed households, but also at females within male headed households. This gives

us a much more comprehensive understanding of the roles and status of women as farmers, producers, sellers and decision-makers.

Our WEAI-inspired survey module focused on decision-making, identified as a central aspect of empowerment (see theoretical discussion on empowerment above). It included a set of questions regarding level of input into decisions made on food crop production, cash-crop production, livestock production, non-farm income generating activity, as well as the use of income from each of these activities. As stated above, there is no clear-cut difference between cash- and food crops in Uganda, so we left it up to the respondent to define what they categorised as food and cash-crop.

Based on this data an empowerment variable was created. It was a continuous variable with values ranging from zero to eight, describing the overall input into decision-making. Zero represented no decision-making power, that is, non-existent empowerment, while eight meant full participation into all decisions made, or very high level of empowerment. This variable was then used in our econometric model, to identify the relationships between empowerment and household characteristics. Several different logistic regressions were run to find the most important variables related to empowerment.

The responses show there is a clear difference between the decisions in which men and women participate. Women have a lot of say in decisions regarding food crop farming, but participate much less than men in decisions regarding the use of income from selling either food- or cash crops. The results are described in more detail and discussed further in the Results section. The contribution to the pathways, implications for policy and continued research of the results are discussed in the final section of the thesis.

Paper II: The Unequal Efficiency Gap: Key Factors Influencing Women Farmer's Efficiency in Uganda.

The second paper uses the same survey data from Uganda as the first one. The focus was again on the realities of women farmer's, this time looking at the determinants of efficiency of women farmers,

compared to that of men or jointly managed plots. The information on farming was collected at the individual level, including management reported at the plot level. 'Plot manager' was defined as the person who made the decision on how the plot should be used, what to grow, when to sell, etc. This made it possible to group plots according to how they were managed, that is by a woman, a man, or jointly. The data was then aggregated to the household level, as it was not common for households to grow maize on several plots under different management systems. Our data thus included 896 observations, out of which 268 represented male managed plots, 260 female managed plots, and 368 jointly managed plots. The goal of the study was to find out if women are less efficient producers, as the literature suggests, and if so, what the determinants of efficiency are, in order to identify the underlying reasons for them. Although it is recognised that there are a range of other factors, in addition to gender, that influence and constrain small-scale famers, the hypothesis here is that there are also gender-specific constraints that inhibit productivity. By identifying these constraints also solutions to increase efficiency can be developed.

The econometric method used for the analysis was the stochastic frontier analysis (SFA), commonly used to measure technical efficiency (TE), as briefly discussed already in the theoretical section above. TE measures how effectively different inputs are allocated to produce a given amount of output, compared to what the potential maximum would be, that is, the production frontier. It is based on a production function, calculating the value of the quantity produced, in relation to the value of the used inputs, including seed, agrochemicals, technology and labour. We tested the suitability of the different functional forms of the production function (Cobb-Douglas, translog and quadratic) and found quadratic to be the most suitable for our data. However, our data does not include information on all the traditional measures of the production function, namely a traditional measure of labour in hours of work is missing. We have therefore adapted the function slightly.

The stochastic frontier model used was based on the one step approach of Battese and Coelli (1995). It identifies the predictors of

efficiency by showing the variables that are significantly associated with higher or lower levels of efficiency. In our model we included a number of individual as well as socioeconomic factors as predictors. We found that there is a clear difference in efficiency between plots managed under the different systems, and that women manage their plots less efficiently. We also found that there are indeed specific factors affecting the efficiency of women. The results are discussed more in the results section.

Paper III: Innovation Platforms: a tool to enhance small-scale farmer potential and women empowerment.

The third paper describes a participatory study completed in Ethiopia as part of the SOILMAN project, funded by the Academy of Finland between 2014 and 2017. The overall goal of the study was to increase the knowledge and use of rhizobia inoculants as biofertilizers among small-scale farmers. When used as an inoculant for legumes, the *Rhizobium*-bacteria allows the legume plant to fix nitrogen from the air (Franche et al. 2009). This is a sustainable, climate-friendly and affordable alternative to chemical fertilizers.

In order to increase the use of rhizobia, both local scientific capacity and farmer engagement needed to be strengthened. One part was capturing the interest of local farmers to actively engaged in testing the technology. A field trial was set up in collaboration with the Southern Agricultural Research Institute (SARI) in the Hawassa region, to evaluate the effectiveness of the rhizobia strains in the field. In addition, a participatory study was launched, involving farmers and other key stakeholders, to find innovative solutions to integrate the use of rhizobia into the local farming system. As part of this innovation process, an Innovation Platform (IP) was established. Participants of the IP included farmers, local extension agents and different experts. The assumption was that compared to traditional extension methods, an IP can better support co-innovation, learning and empowerment, and therefore has better potential to lead to adoption and sustainability. A key requirement of our IP process was that both the man and the woman from each household participated.

This was expected to support women's participation and strengthen the role and empowerment of women in the process. In addition to promoting the use of rhizobia, the aim of the study was therefore, to contribute knowledge about the most useful methods and tools to engage farmers in the innovation process, as well as the implications it had for women farmers.

The project was implemented in the Sidama area, close to Hawassa, approximately 200 km south of Addis Abeba in the lowland areas of the Great Rift Valley. The project area is classified as semi-highland and characterised by small plots cultivated with mixed crops. A commonly grown crop, one of the staple foods of the area, is *enset* or so called false banana. In addition, a number of pulses are commonly grown, and both maize and coffee are inter-cropped on the plots. The trend of growing *chat* as a cash-crop has become increasingly common in the area. This is problematic, as chat requires a lot of sunlight and drives people to cut down trees on their land, with devastating effects for soil-fertility. It also has negative implications for household food security. An additional goal of the project was therefore to motivate farmers to come up with alternative income sources.

Paper III describes the different phases of the project, the types of qualitative data collected as well as an analysis of the participatory method. The data include a formative and a post-intervention survey, in which 60 households participated, reports from all meetings by the IP facilitator, focus group discussions and key informant interviews. We use Eskonheimo's general or flexible definition of a key informant to be "a person who provides the researcher with important additional information due to her/his professional expertise and/or social connections" (Eskonheimo 2006, p.54).

7 Results

The detailed results of the studies are reported in the original publications that are part of this thesis. This section provides a short summary of key results focusing on the aspects contributing most to the overall research questions and to the Conceptual framework. The links and relationships between the results and the thematic areas are described in the Results Framework (Fig. 2).

7.1 Question one: What are the key aspects or characteristics of women empowerment among small-scale farmers?

In paper I we look at individual and household characteristics that are associated with women empowerment. We use a decision-making variable as the proxy for empowerment, derived from responses by a woman in each household regarding her input into decisions made on a range of activities, including the use of income. The definition of empowerment in this context is closely linked to economic issues, as it is based on decisions relating to production and use of economic resources in the household. However, we argue that the participation in decision-making goes beyond the specific issue the particular decision tackles and reflects the role of the woman in the household in a broader sense. Also, decisions relating to production are closely linked to household food security and wellbeing, which are important aspects of women's empowerment. Therefore we see our variable providing a relatively holistic view of empowerment.

The female respondent was most commonly the spouse, or the household head, in case the head was female (18% of households). Which are then the key characteristics related to women empowerment? The significance of the variables varies slightly between the different models used in the study. It is therefore challenging to pinpoint particular individual characteristics. This is in line with the notion that empowerment is indeed a complex issue, influenced by a number of different context specific and culturally defined issues. However,

certain structural factors do emerge clearly as significant drivers of empowerment, or the lack of it.

Some of the most important factors relate to household composition. The 'share of children aged five or less', as well as the share of elderly household members, are both significant and associated with lower levels of women's empowerment. We have interpreted this as reflecting the time burden of women caused by household chores, the bulk of which women are responsible for (e.g. Stoebenau et al. 2014). Mean age (mean of the spouses in the household, which in case of women headed households in practice signifies age of head) is associated with higher levels of women empowerment. This indicates that higher age is associated with higher levels of empowerment. One might assume that younger people are more receptive to new ideas and might be more likely to accept concepts of equality. This is not supported by our analysis. However, the results may also be the reflections of a different culturally defined factors, that is – with seniority comes status. This is in line with Peterman et al. (2015) who found age to be the only variable significantly associated with decision-making in Uganda.

Perhaps the most interesting significant variable in our data associated with higher women empowerment, is educational equality, calculated as female education in years subtracted from male education in years. This is supported by results from Uganda by Meier zu Selhausen (2016) that suggest a gap in education between spouses influences women's choice negatively. This is an important specification to the notion that education of girls and women is a key to development. Educating girls alone may not have the expected impact, if gender parity in education is not also taken into consideration.

Further significant variables include travel time to the nearest paved road, a proxy for remoteness, that is associated with lower levels of empowerment, suggesting the more remote the household is located, the less empowered the women. This is likely due to the exposure to new ideas and ways of life, as well as wider access to information of different kind, that comes with proximity to urban settings. This variable can thus reflect the importance of access to

information. This is supported by the fact that owning mobile phones was positively associated with women empowerment. The growing number of phones in rural areas can significantly improve access to information. Especially as the share of smart-phones increase, it will mean unlimited access to information on a range of issues. Of course, in order to make use of all the new information, education is still a key factor.

The final statistically significant variable associated with women's empowerment is marketed percentage, or the share of the crop produced by the household that is sold, rather than consumed at home. Market share is an endogenous variable, as it is linked to decisions made by the household, which makes analysing the result somewhat tricky. However, it does say something about the relationship between certain types of households and empowerment. The results suggest that more subsistence oriented households have higher levels of women empowerment. This may be linked to the fact that men are more likely to grow cash-crops and therefore have greater control over resources in households with a cash-crop focus. Women in general had much less say when it came to decisions on cash-crop farming, compared to food-crop farming (41% compared to 74% of women report being involved in most or all decisions made). A characteristic seems to be that women's participation is still largely limited to food-crop farming, which inhibits participation in alternative income generating activities and livelihoods.

7.2 Question two: How do these characteristics relate to the productivity and efficiency of farming practices of men and women?

In paper 2 the focus is on efficiency. We first compare the levels of efficiency between women, men and jointly managed maize plots and find there is a clear and significant difference. Women farmer are significantly less efficient than their male counterparts or when working together with males on jointly managed plots. The mean TE of women is also lower than that of men or jointly managed farms. However, when calculating a frontier for only the female group,

taking their available inputs into consideration, the level of TE increases dramatically, suggesting women can be very efficient, given the right circumstances and available resources.

The factors of interest for the research question influencing efficiency in the overall model include women being active in income-generating activity outside the household. This is closely related to the fact that household wellbeing improves when women have personal access to income, as suggested by other studies (Sraboni et al. 2014, Wouterse 2016). Although the link to efficiency is by no means direct, it points towards a tendency where women's active participation goes hand in hand with well-being. This suggests that providing women with opportunities for off-farm activity could be an important contributor to empowerment and wellbeing.

Another overall factor positively associated with efficiency, is share of crops sold. This suggests that plots allocated towards cash-crops are managed more efficiently. This can be seen as an equality issue, as men are more commonly the ones to farm cash-crops, and therefore the ones to benefit from the efficient use of resources on these plots. It is also linked to the question discussed above suggesting women are less empowered in households putting a great deal of focus on cash-crops.

When looking at the factors affecting the efficiency of women in particular, we find that some household characteristics are significant. The time burden factor associated with large households, found to affect women's empowerment negatively, is also significantly associated with lower efficiency. On the other hand the number of children between six and fifteen years of age is positively associated with efficiency on the woman's plot. This may be due to labour input provided by older children towards all plots of the household.

The links between the most important factors related to efficiency and empowerment can be identified by comparing the results from paper I and II. We find that similar factors emerge as significant, suggesting there is a link between empowerment and efficiency, although perhaps not immediately obvious. The pathways will

therefore also be interlinked, as will be discussed more in the following chapter.

7.3 Question three: How can participation in the innovation processes support small-scale farmers', particularly women farmers', empowerment, productivity and visions for the future?

Paper III follows a pilot study in Ethiopia, engaging a group of local farmers, both men and women from each participating household, as well as extension agents and experts from the local university, to test an IP as an alternative extension approach. It was suggested as a way of tapping into the innovation system in order to find the best methods to integrate a new, environmentally friendly technology into the local farming system. The expectation was that the technology would be better received and more likely adopted if people were involved in finding the best solutions for integrating it. Participating in the IP was in itself expected to be an empowering experience.

The research question posed is; how can participation in the innovation processes support small-scale farmers' empowerment, productivity and visions for the future. We start by answering the question **can** participation in the innovation process support empowerment? The evidence from our study in Ethiopia suggests that it can. The study confirms that a much larger percentage of respondents of the post-intervention survey who had been part of the IP reported increased yields. From a methodological viewpoint even more interesting is that all of the respondents said being part of the IP had changed their role in the community. They felt their farming capacity had increased and that their status in the community had developed into that of a model farmer or communicator. This was especially true for the female participants, who became much more self-confident and assertive as a consequence of their participation. According to the key informant interviews many of these women were much more prone to voice their opinion in a range of different situations in the community than they had been before. The added capacity also made them optimistic with a positive vision for the future.

Several of them planned to diversify their production or start small businesses as risk-mitigation measures. Most of the respondents reported being better equipped for future challenges.

This leads us to the actual research question, which is **how** participation can lead to empowerment? It was clear through the study that participation in the IP was instrumental in bringing about change. We found that having tools and mechanisms to support and strengthen the innovation process, is key to supporting active member participation. Facilitation is essential in order to engage participants, as well as giving a structure and clear aims to frame the activity. It is possible that once the platform has established itself, in can develop and reinforce its goals through the capacity, empowerment and new roles internalised by the participants. Another essential factor of IP success, where the facilitator can also be instrumental, is minimizing hierarchical structures, and guaranteeing all members the opportunity to express their views.

An important factor identified through the study was the spill-over effect, relating to community networks. Many of the households in the community taking part in the survey, but not in the IP activity itself, also expected increased income over the next few years. It was clear that information about the technology had spread and even three non-IP households reported having started to plant soybean, which was a crop not previously known to the community and not accessible in the local market. Most likely they had been given seed by one of the IP members. This affirms the importance of the existing networks in the community, through which information is shared, discussed and spread. It also suggests the IP model can be a useful extension tool, as an addition to and supporting the existing communication networks.

7.4 Question four: How can these approaches be used to develop pathways towards sustainability?

The forth question looks at what types of tools or pathways to sustainability can be envisioned and developed based on the insights

from the research questions and case studies. How are the results linked to the overall goal of finding new and useful pathways towards sustainability? The pathways identified through the studies are visualised in the Results Framework in Figure 2.

The pathways discussed here tackle issues at different levels and can as such have quite different functions. Some can be relevant as concrete tools at an applied project level, while some will be of a policy nature contributing information for local and national policy makers as well as development actors and donors in planning strategies, activities and funding schemed in the most useful and targeted ways. The suggested pathways are described here in brief and visualised in the results framework as optional scenarios. A great number of interlinkages also exist between the different pathways. In the discussion section the implications, challenges and potential of the pathways will be discussed at more length, building linkages to ongoing discourse.

When looking at the results it is evident that empowerment, or more specifically women's empowerment, plays a crucial role within the farming system. The first result area therefore focuses on strengthening women's empowerment. Two concrete approaches that could be instrumental in driving the 'empowerment pathway' have been identified. The first one relates to education, the other one to supporting women's participation in market-oriented agriculture or other income-generating activity outside the household. Supporting women in accessing markets is defined in the results framework as 'participation'. It is clearly related to women's time-burden, specifically their household work load. Finding ways to support women's opportunities to actively take part in both market oriented agriculture and other forms of income generating activity is a central aspect of the 'participation pathway'.

Another important factor found to influence empowerment was education, or more specifically the gap in education between the spouses. Education and capacity building, through both formal and informal approaches, is the other pathway found to contribute to empowerment.

The second result area is related to the Innovation System. It promotes innovation capacity of key stakeholders and engaging different actors into co-creation activity. The pathway is operationalised as the establishment of IPs in addition to or as part of the local extension system. In our case study the IP allowed the women to become active members of the innovation system, to achieve new roles in the community and to have higher awareness and levels of empowerment. This supports the goals, specified by the women themselves: access to new technologies that increase productivity, but also to diversify their farming practices and engaging in non-farm activity as a form of risk mitigation (own data). The fact that the role of women is clearly changing, especially in our study context in Ethiopia, may play an important role in speeding up the processes.

There are a number of factors that will influence the potential of these envisioned pathways to develop, and of their likelihood of success. Community dynamics are constantly changing, however a number of cultural and other background factors will influence the acceptance and opportunities for adopting the pathways. Therefore, context specific adaptations of the pathways will be required, developed in collaboration with the local stakeholders involved in the change processes.

8 Discussion on Pathways

The studies featured in this thesis all have the overall goal to identify pathways towards sustainability of small-scale farmers in Africa. Pathways have here been defined loosely as tools and approaches that stakeholders at different levels can contribute to, that can lead to new behaviour, innovations, or other ways to challenge the status-quo, leading to change. The individual studies use different approaches and perspectives, but with the common aim of identifying the most important constraints faced by small scale farmers, especially women farmers, as well as possible tools and pathways to support them in improving their situation.

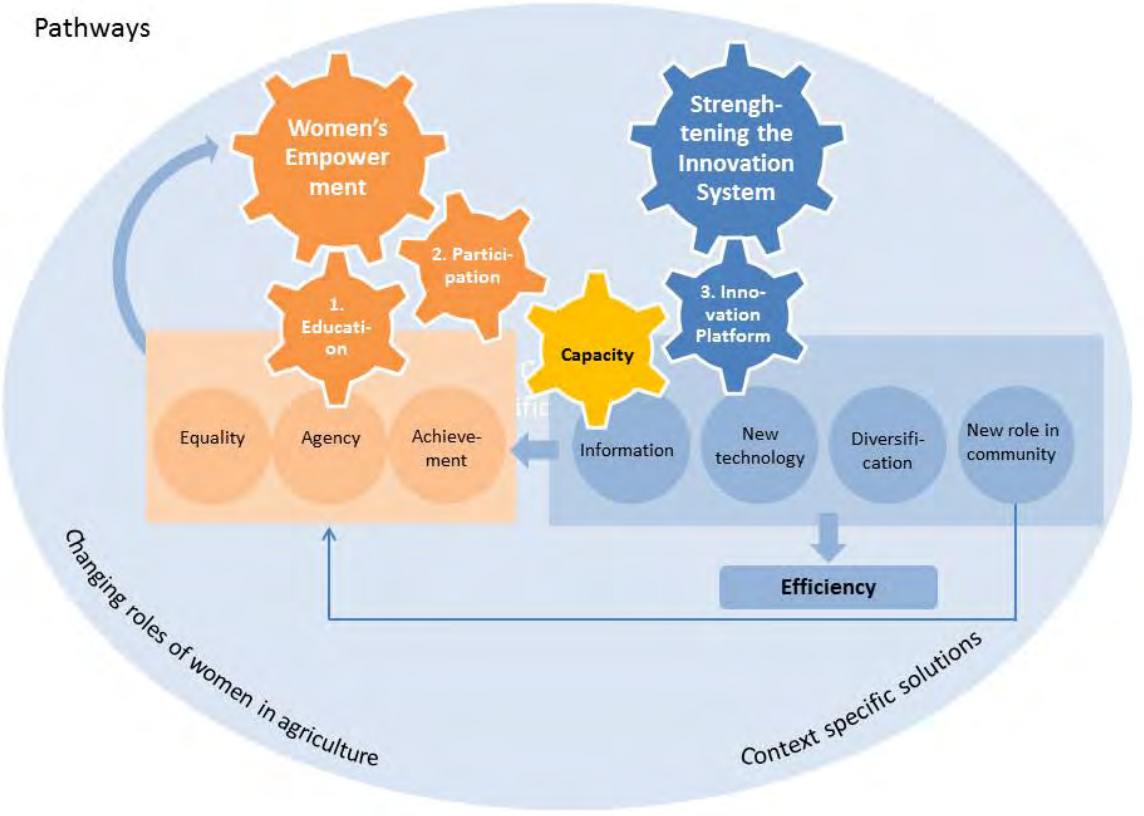

Figure 2. Results Pathways

Although the papers describe specific case studies, the results point to a few key trends that have general applicability and potentially important policy implications, both for local and national policy makers, relating to strategies to support farmers. This final section reflects on the conceptual framework and the implications of the results for the overall research questions.

The discussion works its way back through the research questions and results identified based on the case studies, to discuss the most important implications for each research question and how the pathways might contribute towards new solutions. Three practical pathways have been identified to have potential for providing solutions and tools toward sustainability of smallholder farmers in Africa. Sustainability in this context refers to both environmental sustainability but also social sustainability, from the premise that farming systems have the potential to contribute to both goals. The pathways provide a range of concrete recommendations that can feed back into the research questions of the thesis.

The existence of a gender gap and the importance of women empowerment were highlighted through the study. As sketched out in the conceptual framework, empowerment is linked to a number of factors affecting the wellbeing of small-scale farmers. Empowered women are much more likely to diversify, engage in non-farm activity, thus improving both food security and general wellbeing of the household (Sell et al. 2018). The different studies confirmed what was hypothesised based on the literature about women farmer's constraints. Women own and farm less land, using fewer resources and have less input into decision-making than men do. Women mostly farm food crops, which helps them feed their families, but does not provide them with income and opportunities. They are constrained in terms of time as they take on the bulk of household work, while at the same time less of the household labour is allocated to the plots they manage.

Many of these factors have been identified also in other studies (from various different contexts). The pathways envisioned here focus on

two specific methodological approaches, namely education and participation (Fig. 2).

The first pathway centres on education. All three research questions found an aspect of education to be important for empowerment, efficiency and participation. Although education was not in itself directly associated with empowerment, equality in education had important implications. Households where the educational gap between the spouses was smaller, the women tended to have higher degrees of empowerment. This suggests special focus needs to be put on ways to keep girls in school. According to a report from 2017, for example Uganda attains a very high score in both primary and secondary education enrolment (WEF 2017). However, enrolment is an input rather than an outcome, and therefore not a good indicator in this case. There are significant levels of drop-out among girls, suggesting a gender bias disdvantaging girls (Stoebenau et al. 2014).

An often quoted reason for girls in Africa to drop out of school is teenage-pregnancy. However, in a recent report from Uganda Stoebenau et al. (2014) found other aspects to be much more important. The key determinant was poverty, forcing families to withdraw their children from school. A clear gender difference was identified, where girls were much more likely to be kept at home, as they tend to take on a much larger burden of household work than do boys. This was strongly associated with families' gendered beliefs and expectations, closely linked to the norms of the community (Stoebenau et al. 2014). These gendered expectations affect girls' own gendered beliefs, which in turn affect school performance. A girl's self-rated school performance was also found to significantly influence drop-out tendency or likelihood.

Similar conclusions are made in OECD's country report from Uganda on Discrimination against women, which finds that gender equality is negatively impacted by widespread acceptance and reproduction of social institutions that discriminate against girls and women. Practices and views, for example regarding the distribution of unpaid household work, are so deeply embedded that they are seldom challenged even by women themselves (OECD 2015). This reproduces

gender roles and negatively affects empowerment. Studies have shown that higher levels of education are associated with lower levels of discriminatory attitudes (OECD 2015). Attitudes play a significant part in changing the roles and opportunities of women in society. In many cases this is a pre-requisite for women to become active participants in market-oriented agriculture, or other income generating activities outside the household.

Education was not directly associated with efficiency, which is an interesting and rather surprising result. There are, however a number of possible explanations for this. First and foremost it may be related to the fact that formal education may not be the most relevant entity to support efficiency. Extension and training can have a more important role with bigger impact on efficiency. However, women also access much less extension training than do men, even though it is an issue that has been recognised for a long time (Manfre et al. 2013). This links back to the factor identified above, suggesting that education leads to less discrimination. Indirectly education can therefore have implications for efficiency. In addition, focusing extension activities and training on women could support them in becoming more efficient, but also in diversifying and engaging in market-oriented agriculture (the second suggested pathway).

Education is also important for participation in the innovation system, as a basic level of education is a pre-requisite for capacity to participate actively in innovation processes. Here a link between pathway one and three is build, as the Innovation Platform methodology can in itself be a pathway towards building capacity and strengthening empowerment. Although the discussion here has mainly focused on formal education, as this information was available through the survey and interview data, it is important to note that informal education also may play a key role in contributing to the pathway. The official extension system can contribute a great deal to capacity within the agricultural sector, but also the range of other formal and informal networks that people belong to play a role in knowledge and capacity development.

The second pathway relating to empowerment focuses on women's participation, that is, being able to actively take part in market-oriented agriculture or other income-generating activity outside the household. A clear link between participation and empowerment has been identified through the study (research question one). Women participating in income-generating activity outside the household are more empowered. They tend to make decisions both on participation in income generating activity as well as on the use of the income generated through the activity.

On the other hand there was a negative association between the share of crops sold by the household and women's empowerment. This may appear contradictory, but we have interpreted it to relate to the fact that cash-crop cultivation is still largely a male domain. Households in which a large share of the agricultural production is focused on cash-crop, the role of the woman may be marginalised. This may limit women's opportunities for example to diversify. Therefore we consider supporting women to become more active in market oriented agriculture an important part of the participation pathway.

Also, in relation to efficiency, participation seems to play an important role. Households where women actively participated in non-farm income generating activity, the efficiency on the plot increased. This may be related to a more focused distribution of household labour, which has positive implications for the whole household. This is closely related to the fact that household wellbeing improves when women have personal access to income, as suggested by other studies (Sraboni et al. 2014, Wouterse 2016). Although the link to efficiency is by no means direct, it points towards a tendency where women's active participation goes hand in hand with well-being, therefore suggesting that providing women with opportunities for off-farm income generating activity could be an important issue to focus on, both by science and policy.

Possible unintended consequences need to be analysed, when developing new pathways relating to women's roles. Combaz (2013) warns against women losing control over commodities, once their market

value increases. Therefore, a gender approach is extremely important when designing programs and policy, for example regarding marketing strategies for agricultural products. Both policy makers but also NGOs and other development practitioners need to understand the implications. Awareness raising of all stakeholders is important. Also, women themselves need to be taken on board the processes, involved in defining and developing these strategies. Such gender transformative approaches include capacity building and co-creation, but monitoring and evaluation of the production systems also have an important role to play and should always include gender indicators (Combaz 2013).

It is important to recognise that decision-making and division of responsibility is not always straight forward or unambiguous. Women do play an important role in decision-making. For example, our study shows that 42 per cent of women report participating in 'all' or 'most' decision regarding the spending of income from cash crop production in which they had taken part (paper I). However, this is part of a bundle-of-rights, where one individual seldom has total control or complete ownership or decision-making power (Doss et al. 2013). A single individual rarely holds full ownership or rights, and therefore being part of one aspect of ownership (e.g. management) does not necessarily indicate having power to participate in all important decisions.

In a recent study, Greg Seymour looks at the link between women empowerment and efficiency. He finds that smaller gaps in empowerment between spouses are associated with higher levels of efficiency (Seymour 2017). Although we do not make inference directly about this relationship, we find characteristics linking the two. We find that women participation in non-farm activity is positively linked both to women empowerment and to efficiency.

The third pathway, promoting the integration of innovation platforms into the extension system, specifically contributes to research question three. An IP was shown to be a tool that can support co-creation and innovation among various stakeholders. Through that it can contribute to building the capacity and empowerment of small-

scale farmers. The innovation platform tool can be implemented at many different levels for a range of different domains. Our participatory study worked on a very practical local level, engaging the local extension system and the local community. However, specific IPs can be developed to tackle for example policy issues, with potential to co-create new policy level impacts (Davies et al. 2016, Hounkonnou et al. 2016).

The 'IP pathway' can, however, also have an important role in relation to the first two research questions. The IP methodology can be used to provide a platform or forum for women to share ideas, to learn and to increase their capacity. This is in line with recommendations of both Hill and Vigneri (2009), and Combaz (2013) who stress the importance of strengthening women farmer's groups and/or marketing groups. This can ensure access along the whole value chain, including markets. Building support for women farmers could also potentially tackle the problem of women's risk averseness – a factor that has been identified to inhibit women's market orientation (Gĩthĩnji et al. 2014). An IP could also provide a platform for women where new networks can be formed and even cooperatives or organisations established.

However, the IP needs to fill certain basic criteria and be managed well in order to be successful. This has been found in the literature and was also a conclusion of our study. A key is the common interest and vision of the participants, to promote a common goal. This implies a fair distribution of power among the IP members (Hounkonnou et al. 2016).

When successful, the network formed by the IP can influence attitudes in the community, with possible positive implication for the role of women. Davies et al. (2016) found that increased social capital was a mediator for change. This reflects the interlinkages and synergies between the pathways. They can all be seen to be part of the same holistic framework, influencing the same issues but from different angels and at different levels.

9 Conclusions and Recommendations for Policy and Further Research

One of the key outcomes of this thesis is confirming the insight that inequality and disempowerment of women has negative impact on a range of development factors. It negatively affects efficiency and productivity, as well as many factors that influence household well-being, directly or indirectly. The key policy recommendations of this study are captured in the pathways described above. In addition there are several recommendations regarding further research. Some of the methodological aspects can also be considered useful and taken further by development projects, policy makers or scientists.

In order for the pathways discussed in this thesis to be useful, they have to be further developed and designed to fit the specific context in which they are intended to be used. As the OECD report highlights, there is no 'one size fits all' approach. For example in terms of discriminatory social institutions there are major regional variation in the level and form, even within Uganda (OECD 2015). Also in our data many constraints of women were found to be related to geographical and cultural differences. Different geographical areas may have different ecological premises that influence farmers' potential. This, of course, does not explain differences in empowerment, which is likely to be related to cultural and socio-cultural factors.

Among the pathways identified based on the studies of this thesis, education stands out as a key approach. But the evidence shows that educating women and girls alone is not enough. Equality in education between men and women is another important aspect positively associated with women empowerment. Finding ways to support girls in staying in school is therefore a key policy challenge, both on a local and national level. It could even be an Africa-wide topic that the African Union (AU) could integrate more clearly into their priority settings. But also providing local support, to support women farmers, such as training and extension to increasing their skills, is important. The approach piloted in the Ethiopia study, using Innovation Platforms to integrate new technology through a participatory

process, proved a good way to achieve this. Being an active part of the innovation system raised both awareness and empowerment of the participants, especially the female participants, and prompted them to take on new roles in the community. It also gave them new skills, which will allow them to plan their agricultural systems better, for example through diversification.

It is clear that the role of women in agriculture is changing. Our studies identified change processes relating to the role of women, especially in Ethiopia. This may lead to a range of new opportunities, yet to materialise. At this point it is difficult to predict what direction this development will take. If adopted into projects and policy, the pathways identified by this study can each contribute to the ongoing process of changing women's roles in agriculture.

One of the reasons for the changing roles is the growing numbers of men working either part- or full time outside the agricultural sector. It is possible that this will allow women to take a larger role in cash-crop farming in the future. Diversification is another risk mitigation method that women, as they become better aware and more empowered, can increasingly start to utilize. From there the step to engage also in non-farm income generating activity is shorter.

There are, however, still challenges for the 'participation pathway', which encourages women to become involved in market oriented agriculture as well as non-farm income generating activities. For example the fact that women carry the brunt of the household burden is likely to be a limiting factor. This can be considered one of the discriminating social institutions that prevent equal access and opportunity. These structural factors are to a large extent culturally shaped. To support the implementation of the pathway, interventions therefore need to target both structural issues and attitudes. This may entail providing women with access to training, resources, and credit. Attitudes are more challenging to target. A key is empowering women to see themselves as active agents, for example agricultural producers. An equally important issue is engaging men to realise the overall benefit of such a change.

One of the lessons from the 'IP pathway' is that extension approaches need further development and support. The tools and methods for extension and training need to become more inclusive, involving both men and women. A traditional top-down method is no longer an alternative. One of the key recommendations relating to extension is to train extension agents to facilitate activities with farmers based on Innovation Platform methodology (paper 3). The capacity of these groups could be strengthened both to develop and adapt technologies in response to context specific needs. The IP methodology can in itself be a tool also for this, linking back to pathway number two.

Networks are found to be central mechanisms of communication, playing an important role in forming opinions and decision-making processes. They also greatly influence attitudes and values, and therefore have a role both in improving farming practise, but also in the empowerment discourse. Making use of these existing networks should be a priority also for new activities and when developing innovation systems and other pathways.

The work presented in this thesis is linked to a number of interesting themes that would merit further discussion and could potentially lead to both concrete policy recommendations but also to new scientific studies. Much more could be said for example about access and control over resources, for example land. Land could not be studied empirically as part of this work, and will therefore be left as a suggestion for future studies. More work certainly needs to focus on empowerment, decision-making, and efficiency in relating to land and resource ownership.

There are a lot of statements in the development discourse, such as gender should be mainstreamed into strategies and funding (see e.g. Combaz 2013), women's access to land should be improved (e.g. Hill and Vigneri 2009). Combaz highlights issues such as securing land tenure and legal awareness of women, and making interventions and markets 'work for women'. Similar suggestions are made by Hill and Vigneri (2009). However, calling such statements 'promising approaches' without providing concrete recommendations, is a bit problematic.

A small detail, but potential interesting future opportunity is that the number of phones owned by the household is positively associated with women's empowerment. As the numbers of phones in rural Africa is growing rapidly, already reaching number such as 60% in rural Uganda, this can potentially have important implications for communication and information sharing. Mobile technology can lead to significant change by providing people easy access to information. This can change marketing patterns, but also attitudes. This is extremely relevant for women farmers, who tend to have more constraints in reaching markets. The details of how these tools could be developed are outside the scope of the work presented here, but an interesting theme for future study.

The gender gaps between men and women relating to access and time burden are identified in this work as inhibiting female farmers. Education, participation, and communication emerge among the most important tools to tackle the gaps. Both men and women need to realise the implications for overall household wellbeing that inequality leads to and the potential benefits equality could have for all. This realisation could be the key to unlock the motivation required to start changing decision-making patterns and behaviour.

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Paper I

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What factors explain women's empowerment?

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What factors explain women's empowerment? Decision-making among small-scale farmers in Uganda

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ABSTRACT

Evidence from studies on women's empowerment suggests that when women have a larger role in decision-making, household well-being improves. Understanding patterns influencing women's empowerment in rural areas is therefore important. We use gender-disaggregated survey data from rural Uganda to explore individual and household characteristics associated with women's empowerment. We find links between empowerment and age, education, proximity to a paved road as well as the marketed share of crop production. Age and education are associated with higher empowerment, but equality in education between the spouses is more important than the average level of education. Remoteness is associated with lower women's empowerment, as is greater commercial orientation in crop production. This may be due to the fact that men are more involved in cash-crop activities, giving them an advantage through higher income. One policy implication is that education needs to target both girls and boys, especially in remote areas, putting special focus on girl's involvement in value added activities.

Introduction

Women play a key role in agriculture. They account for 43% of the agricultural labour force in developing countries (FAO, 2011). In Africa they are considered responsible for producing up to 80% of the locally consumed food (Palacios-Lopez, Christiansen, & Kilic, 2015). However, a large number of studies on women's role in agriculture have highlighted gender gaps in asset ownership, education, access to credit and extension services, which causes female farmers to be less productive (Quisumbing, 1996; Doss, 2001; World Bank, 2001; FAO, 2011; Quisumbing et al., 2014). These gaps affect income and intra-household distribution, with possible negative effects on education, health, and nutritional status in the households (Sraboni, Malapit, Quisumbing, & Ahmed, 2014). Thus, the gender gap in agriculture may have long-term implications both from an economic and a development perspective (Manfre et al., 2013).

In order to support women farmers through policy measures, it is essential to understand the dynamics driving the gender gap. Many studies suggest that the gender gap is largely linked to issues relating to women's participation and empowerment (Manfre et al., 2013; OECD, 2015). There are a number of individual, household, and community characteristics that are likely to influence women's empowerment. Identifying, examining and understanding these determinants is a first step in exploring strategies to reduce gender inequality and promote food and nutrition security. Analysis of women's empowerment therefore needs to be a key aspect of any work in agricultural development.

The aim of this study is to examine some of the key determinants of women's empowerment relating to an agricultural context in Uganda. We use gender-disaggregated survey data from approximately 1440 households in rural Uganda. Using regression analysis, we identify key variables related to empowerment. The survey included an adapted version of the Women's Empowerment in Agriculture Index (WEAI), originally developed for the Feed the Future Program of the United States Agency for International Development (USAID) (Alkire et al., 2012; Alkire et al., 2013). This study also aims to provide insights on using the WEAI as a tool. The results contribute to the literature on women's empowerment and the gender gap in agriculture. It provides input for the design of agricultural extension activities, programs and policies, thus contributing towards improved empowerment, productivity and household wellbeing.

Women's empowerment

Most definitions of empowerment focus on resources, agency and achievement. Resources refer to control over physical, financial, human and intellectual resources (Kabeer, 1994), while agency implies having

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the capability and freedom to make individual life-choices (Desai, 2010; Sen, 1992; Sen, 1999; Sen, 2009). Together agency and resources constitute achievement, or "functioning achievements", which is related to universally shared basic functionings, but also refers to individual preferences (Kabeer, 1999).

Scientists in the field generally agree on a few key factors that determine or influence empowerment. These include age, gender, marital status, nationality, social role, economic activity, intra-household distribution, and health (Sen, 1992; Sen, 1999; Sen, 2009; Kabeer, 1994; Trommlerová, Klasen, and Leßmann, 2015). Another factor often considered a key element of empowerment is participation in economic activities. Control over resources does not automatically lead to empowerment, but can be a "catalyst for empowerment" (Malhotra, Schuler, & Boender, 2002). While "resources—economic, social, and political—are often critical in ensuring that women are empowered, they are not always sufficient. Without women's individual or collective ability to recognize and utilize resources in their own interests, resources cannot bring about empowerment" (p.9, Malhotra et al., 2002). However, access to and use of resources, is a central theme within the empowerment discourse. Sociological theory has emphasized the relationship between resource control and empowerment on a household level, but also looked at the socio-cultural environment for explanatory factors (Khan and Awan, 2011).

However, it has been suggested that households do not allocate intra-household resources in a fair or even optimal manner, but that power relations play an important role. Household welfare outcomes may depend on the preferences of the person with power (Wouterse, 2016). Therefore, having a voice in intra-household decision-making can be considered an inherently meaningful dimension of empowerment, since it may be desirable in its own right and it can also determine directly how resources are allocated within the household (Peterman, Schwab, Roy, Hidrobo, & Gilligan, 2015, p. 1).

Owning productive resources has been found to strengthen a woman's bargaining position in the household (Meier zu Selhausen, 2016). Land is one such key resource, and women's access to land is therefore an important determinant of empowerment. What it means in the Ugandan context will be discussed further below.

Measuring empowerment and the WEAI

As discussed above, an important part of any research on African agriculture is to understand how gender patterns in agriculture work and how they are changing (Doss, 2013). Although quantifying subjective concepts like women's empowerment and gender equality is difficult, it is necessary in order to influence policy change and measure impact. To do so, relevant and reliable data specifically targeting the realities of women is required. Household surveys have been criticized for using household-level income and consumption data as measures of poverty, rather than recognizing poverty as multi-dimensional, experienced differently by different household members (McGee, 2004). Such an approach bypasses the realities and challenges of women within male-headed households, although it is recognised that "gender inequalities undermine the effectiveness of development policies in fundamental ways" (World Bank, 2001 p. xiii).

A number of methods, measurements and indices have been developed by different scholars and development actors over the years. Often education or employment have been used as proxies for empowerment, but should rather be seen as enabling factors than empowerment outcomes.

In 1995 the United Nations Development Programme (UNDP) Human Development Report (HDR) for the first time integrated measurements on women's empowerment, including the gender-related development index (GDI) and the Gender Empowerment Index (GEM) (UNDP, 1995). They have however been criticized for being too limited in scope and lacking many key aspects of empowerment, including women's participation in community and household decision-making and resource use (Shüler, 2006; Syed, 2010). In response to these criticisms, new gender indicators were included, and also many other measures and matrices were developed (Charmes & Wieringa, 2003).

The Women's Empowerment in Agriculture index (WEAI) was originally developed for the Feed the Future program of USAID in 2012 by International Food Policy Research Institute (IFPRI) and Oxford Poverty and Human Development Initiative (Alkire et al., 2012; Alkire et al., 2013). The WEAI is constructed as an index consisting of five different areas or domains of empowerment, namely *Production, Resources, Income, Leadership* and *Time*, as well as a gender-parity index (GPI). The GPI compares the levels of empowerment between women and men in the same household, which gives an indication to what extent disempowerment, can be considered a specifically gender-related phenomenon as opposed to being a characteristic of the household as a whole. This is possible due to the fact that the WEAI methodology involves asking the same questions of both a man and a woman in the same household.

The overall empowerment score reflects the weighted percentage of dimensions in which a person has achieved adequacy. However, each domain can also be calculated separately in order to analyse the level of empowerment within a particular area. Economic empowerment, specifically ownership and decision-making, are the key domains of the WEAI. It specifically «captures control over resources or agency within the agricultural sector, something which existing indices have not done» (Sraboni et al., 2014, p. 13).

The WEAI can be used as a diagnostic tool for policymakers, development organizations, and academic seeking to increase women's empowerment (Sraboni et al., 2014). It can serve to identify types of households (defined by location, occupation, or other characteristics) in which women are disempowered (Malapit et al., 2014). In the past couple of years an increasing number of studies have used the WEAI to look at how specific development issues are linked to empowerment (e.g. Sraboni et al., 2014; Wouterse, 2016). The approach focuses on identifying underlying problems rather than looking only at the effects. This can help direct policy in targeting core challenges.

Uganda

The Ugandan economy, like many in Sub-Saharan Africa, is highly dependent on agriculture, with a population relying heavily on agriculture for their income. Out of the total working population (13.9 million people aged 14–64), 43% work in subsistence farming, and 72% of the employed population is employed within the agricultural, forestry and fisheries sector. There is a clear gender divide in employment with only 39% of women employed, compared to 54% of men (UBOS (Uganda Bureau of Statistics), 2014).

Coffee is the main export crop, which is commonly intercropped with other crops on small farms. Most small-scale farmers grow cassava, sweet potatoes, and matooke (plantain) for home consumption as well as maize and beans for both consumption and sale (Peterman, Quisumbing, Behrman, & Nkonya, 2011). According to FAO Food Balance Sheets, the four most important sources of calories in the Ugandan diet are maize, plantains, cassava, and sweet potatoes (FAO, 2013).

In terms of land ownership, 80% of the land in Uganda is still held under unregistered customary law, dating back to pre-colonial times. Only a small minority of people have official land titles to back up their tenure today. No single precolonial land-tenure system can be identified, as different ethnic groups had various practices based on different cultural traditions. Under customary law women usually have fewer rights to land and generally do not inherit it from either their fathers or their husbands. Therefore, "women often have only secondary claims to land, obtaining user rights through husbands, sons, or other male relatives" (Doss, Meinzen-Dick, & Bomuhangi, 2014, p. 83).

This is important as studies on women's land rights have identified a correlation between secure land rights and income, both net farm income and off-farm income. However, several different definitions of

land ownership exist. It is useful to look not only at ownership but also at control of land and the benefits derived from that land (Doss et al., 2014). In most cases it is rare for a single individual to hold full ownership and control of land. Doss et al. (2014) found that 52% of plots were reported as 'jointly owned', although only 7% had both names listed on the ownership documents. This was also reflected in the fact that women reported a much higher level of uncertainty about future access to land.

In terms of education Uganda has made great progress in universal enrolment, with 91% for primary school children enrolled (OECD, 2015; World Economic Forum, 2017). However, when reaching secondary levels, the gap between girls and boys widens. In practice, dropout rates of girls, especially from secondary education, are significantly higher than those of boys (Stoebenau, Warner & Sexon, 2014; OECD, 2015).

Uganda was one of the pilot countries for the WEAI. According to the WEAI baseline report only 58% of women in Uganda have achieved adequate empowerment scores (Malapit et al., 2014). The domains that most contribute to disempowerment of women are control over use of income, workload, and access to and decisions regarding credit.

Data and methods

The dataset used for our analysis is part of a household survey we conducted covering approximately 1440 households in eight districts of Uganda during December 2012 and January 2013. The eight districts were selected purposively to represent the eastern, central, and western regions of the country (Fig. 1). Within each district, 18 rural local councils (an administrative unit equivalent to a town) were selected randomly from a complete list of rural local councils. Within each local council, 10 households were selected randomly from lists maintained by the local-council authorities. The data were collected through individual interviews (in most cases the head or spouse) by enumerators, trained by the project partners. Approximately half of the enumerators were male and half female. The survey households were randomly assigned to the enumerators, and the sex of both respondent and enumerator was therefore random. In most cases the enumerators mastered the local language. In 9% of cases a local translator was involved in the interview situation.

In addition to the household-level questionnaire, a modified WEAI module was included, to which both a male and female in the household was asked to respond. In most cases it was possible to interview the respondents individually without interference of other people. The questions focused on decision making, more specifically the levels of input into decisions made about productive decisions as well as decisions regarding the use of income from these activities. Based on women's empowerment literature (as described above) we decided to use decision-making as the basis for our empowerment variable. Participation in the following activities were included in the survey; food crop farming, cash crop farming, livestock raising, non-farm self-employment, and wage and salary employment. Response options for each activity are *no input, input into few decisions, input into some decisions, input into most decisions,* and *input into all decisions*, corresponding to the values one to five.

Based on the responses regarding participation, we constructed a decision-making index (DI) that combines information on the individual's role in production decisions and decisions about the use of income from each activity. The DI is calculated by adding up the responses for all of the decision-making questions, on activities in which the respondent has participated, divided by the number of activities. We then subtract by two to achieve scores between zero and eight, as specified in the equation below.

$$DI = \frac{\sum_{i=1}^{N} (PD_i + RD_i)}{N} - 2$$

where PD_i is the level of input into production decisions regarding activity i, RD_i is the level of input into revenue allocation decisions regarding activity i, and N is the number of economic activities of the household (maximum 5).

The equation includes only the activities in which a given individual has participated, giving them equal weight. An option would have been to give more weight to wage and salary labour, or to participation in several activities, both factors associated with empowerment. However, we decided that for our context, in which most participants have only limited access to a variety of income generating activities, decision-making in the activities in which they actually do participate is the most relevant.

We also collected information on membership in different groups present in the community and on time-use, based on the modified WEAI questionnaire.

Conceptual framework

Our conceptual framework is based on the idea that women's empowerment is influenced by a combination of individual, household, and community characteristics. Empowerment, in turn, can have important impact on productivity and resource use, which according to literature may affect the overall wellbeing of the household, particularly that of women and children.

Access to resources and input into decision making are both key components of women's empowerment. On the one hand, they will influence productivity directly; on the other hand, they may influence intra-household distribution and resource allocation, which in turn will also affect productivity. Productivity, in turn, affects total income of the household, which has a great influence on the overall household wellbeing. But intra-household distribution and resource allocation also has a direct impact on the wellbeing of individual members, such as women and children.

In this paper, we focus on the relationship between a range of individual, household, and community characteristics and women's empowerment levels. By identifying the central characteristics associated with women's empowerment, we can better understand the key constraint to women's empowerment and how it may be linked to other aspects of well-being, including income generating opportunities, access to inputs and education. The survey data do not include information to complete an in-depth analysis of well-being. We have included it in our framework as a potential outcome and an area to focus on in future studies. Based on our analysis we hope to identify the areas that should be targeted by interventions and what type of interventions would be the most useful to support women's empowerment in agrarian economies or contexts, whether relating to issues such as women's education in general or to issues relating to farming practices.

Empirical specification

We start by simply comparing the responses of men and women regarding decision-making, both for the individual activities and for the aggregated empowerment variable using pairwise test. We also calculate the gender parity index (GPI) at the household level, in the cases where there are responses from both spouses.

We then move to regression analysis using the empowerment variable as dependent variable. Rather than define empowerment as a binary variable based on a defined threshold level for empowerment, as in the original WEAI, we examine empowerment as a continuous variable, similar to what Sraboni et al. (2014) do in their analysis of Bangladesh. The regression analysis uses a range of characteristics as possible explanatory variables for empowerment. More specifically, the following equation is estimated:

$$E_i = \beta_0 + \boldsymbol{\beta_1 x_i} + \boldsymbol{\beta_2 h_i} + \boldsymbol{\beta_3 c_i} + \varepsilon_i$$

where E_i is our aggregated empowerment variable for the woman in

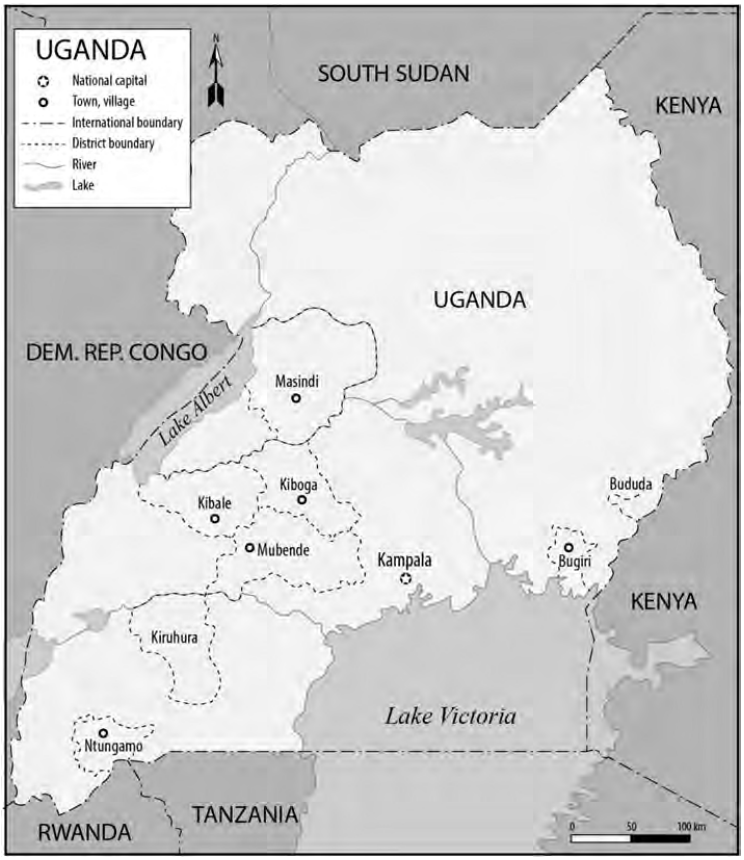

Fig. 1. Map of Uganda highlighting study districts (©Magdalena Lindberg).

household i, $\boldsymbol{x_i}$ is a vector of individual-level characteristics of the woman in household i, $\boldsymbol{h_i}$ is a vector of household characteristics for household *i*, $\boldsymbol{c_i}$ is a vector of the community characteristics for household i, and ε_i is an error term, which is assumed to be independently and identically distributed with a normal distribution. The βs are coefficients to be estimated.

The vector of individual characteristics includes age and education of the woman in the household. These are factors commonly associated with empowerment, which we also expect to be significant in our study. The household characteristics include the share of household members in different age categories, which we are assuming to be related to women's time burden. The age and educational level of the household head, the difference in age and education between the spouses, farm size and a dummy variable for access to electricity are additional household variables. Also factors, such as value of inputs and labour, size of farmland owned by the household, as well as household income are included in this vector. These are variables related to the farming system of the household, many of which may be considered endogenous. Because of this endogeneity, we cannot necessarily interpret the results as demonstrating a causal relationship between these factors and women's empowerment. The community vector includes the travel-time to the nearest paved road, to describe remoteness, a variable used also in other studies (e.g. Wouterse, 2016). This variable can be associated with several other factors, such as access to markets, information and other income generating opportunities. A difference in opinions and values can usually be found between urban and rural communities (OECD, 2015). Presumably there are also differences between rural communities, which may be related to how isolated and remote the communities are. In one of the models (Model 2) a set of dummy variables representing the districts are included, while in model three languages are included to represent cultural differences.

The independent variables are tested for multicollinearity, through variance inflation factor test (VIF), and the residuals are tested for heteroscedasticity using the Breusch-Pagan/Cook-Weisberg test.

Results

Descriptive statistics

In Tables 1 and 2, some basic summary statistics of the data are presented to give an overview of the population. The households represent small-scale farmers whose main activity is crop production. Most of the households are involved in mixed farming, growing both food crops and cash crops (Table 2). Female-headed households represent 18% of all households.

Based on the data, food security is a serious problem in Uganda. Almost half (49%) of the households reported having experienced at least one hungry period during the past 12 months. Of these households, 25% also experienced a second hungry period. Hungry periods were experienced in all regions of the survey, although some

Table 1
Descriptive statistics of survey households.

Variables	N	Mean	Std dev	Min	Max
Household size	1421.0	6.4	2.9	1.0	20.0
Members 5 yrs. and under	1421.0	1.3	1.1	0.0	6.0
Members 6–15 yrs. old	1421.0	2.2	1.8	0.0	12.0
Members 16–19 yrs. old	1421.0	0.6	0.8	0.0	4.0
Member 20–60 yrs. old	1421.0	2.1	1.1	0.0	9.0
Members over 60 yrs	1421.0	0.2	0.5	0.0	4.0
Sex of head of household	1421.0	82.3	38.2	0.0	100.0
Age of head of household (years)	1421.0	45.2	15.7	17.0	99.0
Age of spouse (years)	1101.0	35.4	12.6	16.0	90.0
Education of head of household (years)	1398.0	5.2	3.7	0.0	14.0
Education of spouse (years)	1095.0	4.6	3.4	0.0	14.0
Head can read English (%)	1421.0	33	0.47	0	1
Head can write in English (%)	1421.0	32	0.46	0	1
Age difference between spouses (years)*	1101.0	7.7	7.1	−32.0	46.0
Difference in education between spouses**	1075.0	1.1	3.5	−13.0	14.0
Household heads engaged in nonfarm activity	1421.0	0.3	0.4	0.0	1.0
Share of spouses engaged in non-farm activity	1101.0	0.1	0.3	0.0	1.0
Household has electricity	1421.0	0.1	0.3	0.0	1.0
Household owns phone	1421.0	0.7	0.5	0.0	1.0
Time to paved road (minutes)***	1384.0	99.5	95.0	0.0	1440
Time to weekly market (minutes)***	1372.0	54.8	49.4	0.0	360.0
Time to district capital (minutes)***	1395.0	104.1	87.1	0.0	1440
Farm land owned (ha)	1421.0	2.2	4.1	0.0	46.9

* Calculated as the age in years of the woman subtracted from the age in years of the man.

** Calculated as the years of education of the woman subtracted from the years of education of the man.

*** Time in minutes using the normal mode of transport.

Table 2
Household crop production.
Source: data from IFPRI Household Survey 2012/13.

Crop	Percent of farmers growing crop (%)	Share of cultivated area (%)	Share of value of crop production (%)	Share of value of crop sales (%)
Rice	2	1	1	2
Maize	67	32	14	20
Finger millet	4	3	0	0
Sorghum	4	1	0	0
Beans	80	16	10	8
Ground nut	29	6	4	4
Soya beans	3	0	0	0
Cabbage	2	0	0	1
Tomatoes	2	0	1	1
Onions	2	0	0	1
Pumpkins	2	0	1	0
Other vegetables	3	1	0	0
Sugarcane	3	2	11	20
Irish potatoes	7	1	1	0
Sweet potatoes	31	6	3	1
Cassava	23	9	3	2
Yam	6	0	0	0
Papaya	4	0	0	0
Cooking bananas	58	12	37	24
Sweet bananas	4	0	1	1
Mango	10	0	1	0
Avocado	7	0	0	0
Other fruit	12	1	2	1
Coffee	32	6	8	14
Other crops	3	1	1	1
Total		100	100	100

geographical differences were found. Kibaale was the least hungry region, with only 18% experiencing hungry periods, in contrast to the hungriest region, Ntungamo where 81% were food insecure. Although both districts are in the Western Region, Ngtungamo is quite mountainous and densely populated, which may help explain the high levels of food insecurity.

Table 2 shows the percentage of households growing each of the most common crops, the share of land allocated to each crop, and the contribution of each crop towards total value of crop production and the total value of crop sales. Maize, beans, and cooking bananas are each grown by a majority of Ugandan farmers. Coffee, sweet potatoes, groundnuts, and cassava are each produced by more than one-quarter of farmers. The most important cash crops among the survey household are cooking bananas, maize, and sugarcane. It is interesting to note that staple food crops (particularly cooking bananas, maize, and beans) account for more than half the value of crop sales. This result highlights the fact that the distinction between food crops and cash crops is not clear cut. Although coffee is the main export crop, it represents just 14% of the total value of crop sales.

Empowerment

Empowerment is analysed based on the responses regarding decision making. This means only respondents in the individual survey are included, in most cases the head of household and spouse. The number of observations differs from that in Table 1 as not all households responded to the individual survey.

As a first step, we look at the levels of participation by men and women in the various activities, presented in Table 3. There is very little difference in the self-reported participation of men and women in food production (94% of women and 92% of men). For all other activities, the percentage of men involved is slightly higher than that of women.

Even though the differences are not very large for most of the categories, there is a statistically significant difference between men and women's participation. For non-farm income generating activity the difference is significant also at the 1% level with 37% of men, but only 18% of women, participating. Very few respondents, either male or female, report income from wage or salary labour. Agriculture and livestock represent the overwhelming majority of income among rural households in Uganda.

Table 4 presents the reported levels of input into decision making on both production and use of income for the activities in which each respondent has participated. The smallest difference between men and women is found for decisions concerning production of food crops. 57% of both women and women report input into all or most decisions on food crop production. For cash-crops the difference is larger (46% of women and 68% of men).

When it comes to decision on the use of income men clearly have a greater role than women. Only 41% of women report input into all or most decisions on use of income from cash crops compared to 74% of men. The only exception is decisions on use of income from wage and salary labour, where women report having input into all or most decisions in a similar proportion to men (88% for men and 82% for women). Although the number of cases for this is quite low ($N = 50$ females), this is an important result, as it suggests that given the opportunity for wage labour outside the household, women may be better able to control the use of income.

The Empowerment variable suggests there are differences between the level of decision making of men and women (Table 5). However, there is also a significant difference between the empowerment levels of men and women in different roles within the households. When comparing values for male and female household heads, we find that women have a higher mean empowerment level. This is likely due to the fact that female-headed households tend not to have a second adult with whom to share decisions, whereas there are very few male-headed

Table 3
Participation in household activities (column percentage).
Source: data from IFPRI Household Survey 2012/13.

Participation	Activity and gender									
	Food crops		Cash crops		Livestock		Non-farm activities		Wage employment	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
No	6	8	47	38	35	32	82	63	95	92
Yes	94	92	53	62	65	68	18	37	5	8
Total	100	100	100	100	100	100	100	100	100	100
N =	1011	965	1011	964	1011	964	1011	964	1011	964

households without a spouse. Sons and daughters both have significantly lower levels of empowerment.

The Gender Parity Index (GPI) was calculated for the households where two respondents participated in the individual questionnaire (only 30% of households). Among these households, 25% reported low or no difference in the level of empowerment between the spouses, while in 50% males are slightly and in 25% significantly more empowered than their wives.

The relatively small reported difference in empowerment between the spouses is in line with findings from other recent studies from Uganda. For example, Doss et al. (2014) found that 52% of plots were reported as jointly owned, although this was not reflected in official ownership documentation. This may partly be linked to a rising awareness, as well as greater dissatisfaction, among women regarding their rights (McGee, 2004), which may prompt them to respond in a way that reflects the direction in which they hope the situation is developing.

Regression analysis

To identify household characteristics that explain women's empowerment, we use regression analysis with the aggregate female empowerment indicator as the dependent variable. Only households where a woman responded to the individual survey are included in the analysis. A number of different regression models are run to try to identify the most relevant explanatory variables. Depending on which variables are included in the model, the number of observations varies due to the fact that each model includes only the observations that have responses for all variables. Here we include three models (Table 6): Model 1 includes a wide range of different variables, including some that may be endogenous, Model 2 excludes potentially endogenous variables, but includes regional dummy variables, and Model 3 excludes potentially endogenous variables but includes language dummy variables. The results of the tests for multicollinearity and heteroscedasticity show that these are not a problem.

Table 5
Mean empowerment scores for different groups.
Source: data from IFPRI Household Survey 2012/13.

Variables	N	Mean	Std dev	Min	Max
Male household head	821.0	6.0	1.3	1.0	8.0
Female household head	240.0	7.0	1.4	2.0	8.0
Male spouse	47.0	4.6	1.8	0.0	8.0
Female spouse	658.0	4.5	1.6	0.0	8.0
Son	23.0	3.2	1.6	0.0	6.0
Daughter	37.0	3.0	2.4	0.0	8.0

One variable is farm size, measured in hectares, as reported by the respondent of the household survey. One percent of farms were reported to be over 48.5 ha, the largest one reportedly 606 ha. As these outliers excessively influence the results, they are dropped from the analysis. We also tested including the logarithm of farm size. However, farm size is not found significant in any of the models.

Household size, that is the number of household members, is not a statistically significant variable, but the share of children aged five or less is statistically significant in Model 1 at the 10% level. A large share of children is weakly associated with lower levels of women's empowerment. The share of elderly members of the household is significant at the 5% level. A large share of older members is associated with lower women's empowerment. Perhaps the presence of older members of the household dilutes the decision-making role of female spouses. Also in Models 2 and 3, the share of household level members aged 15 or less, that is children of all age groups, is significant. However, these cases are associated with higher levels of women's empowerment. This seems to

Table 4
Input into production decisions and decisions on revenue allocation in relation to each activity. Column percentage.
Source: data from IFPRI Household Survey 2012/13.

Male respondents	Food crop	Dec food	Cash crop	Dec cash	Livestock	Dec livestock	Non-farm activity	Dec non-farm	Wage and salary	Dec wage salary
Male respondents										
No input in decisions	2	3	0	1	1	2	1	1	0	3
Input into very few decisions	7	7	5	4	9	7	1	1	4	1
Input into some decisions	34	29	27	21	31	25	9	11	5	8
Input into most decisions	42	41	46	45	37	38	26	30	21	24
Input into all decisions	15	20	22	29	22	28	63	58	70	64
Total	100	100	100	100	100	100	100	100	100	100
N =	884	884	596	596	650	650	367	367	76	76
Female respondents										
No input in decisions	2	5	4	10	4	8	9	9	8	8
Input into very few decisions	9	11	16	17	15	16	10	9	4	2
Input into some decisions	33	30	35	32	34	31	20	22	10	8
Input into most decisions	34	30	28	21	25	21	22	21	27	32
Input into all decisions	23	23	18	20	22	23	40	40	52	50
Total	100	100	100)	100	100	100	100	100	100	100
N =	951	951	538	538	653	653	189	189	52	52

Table 6
Determinants of women's empowerment.
Source: data from IFPRI Household Survey 2012/13.

Independent variables	Model 1	Model 2	Model 3
Number of Household members	0.029		
	(0.94)		
Share of members aged 5 years or less	−1.058		
	(1.72)*		
Share of members aged 6–15 years	−0.016		
	(0.03)		
Share of members aged 16–19 years	−1.026		
	(1.50)		
Share of members aged over 60 years	−1.632		
	(2.13)**		
Share of household members 15 years or less		0.675	0.609
		(1.97)**	(1.75)*
Mean age of household head and spouse	0.021	0.022	0.021
	(2.64)***	(3.79)***	(3.63)***
Age difference (male head-female spouse)	0.010	0.015	0.014
	(1.06)	(1.62)	(1.49)
Mean years of education of household head and Spouse	0.280	0.023	0.026
	(1.12)	(0.99)	(1.01)
Difference in education between spouses (years of head – years of spouse)	−0.041	−0.042	−0.040
	(2.18)**	(2.31)**	(2.18)**
Male head involved in nonfarm activity	0.080		
	(0.59)		
Female spouse involved in nonfarm activity	−0.032		
	(0.15)		
Household owns phone	0.211	0.254	0.259
	(1.36)	(1.73)*	(1.71)*
Time to paved road	−0.002	−0.002	−0.003
	(3.29)***	(2.70)***	(3.54)***
Farm land owned by household (ha)	−0.023	−0.025	−0.029
	(1.39)	(1.50)	(1.77)*
Marketed percentage of yield	−0.011		
	(4.69)***		
Value of bought inputs in USD	0.000		
	(0.06)		
Value of bought labour in USD	0.000		
	(0.13)		
Value of non-farm income in USD	0.001		
	(0.31)		
Value of per capita income in USD	0.000		
	(0.65)		
Mubende		−0.227	
		(0.99)	
Bugiri		0.460	
		(1.93)*	
Buduuda		0.563	
		(1.80)*	
Kibaale		−0.067	
		(0.26)	
Masindi		0.721	
		(3.02)***	
Kiruhura		0.925	
		(3.57)***	
Ntungamo		1.053	
		(4.62)***	
Acholi/Lango/Luo			0.704
			(1.97)**
Alur			0.719
			(2.41)**
English			0.384
			(1.85)*
Kifumbira/Kinyarwanda			−0.457
			(1.32)
Lugisu			0.274
			(1.03)
Lusoga			0.136
			(0.62)
Runyankole/Rukiga			0.749
			(4.96)***
Runyoro/Rutoro			−0.030
			(0.18)
Samia			0.332
			(1.11)
Constant	4.151	2.751	2.848
	(9.06)***	(6.73)***	(6.93)***
R^2	0.13	0.15	0.12
N	582	582	582
Wald test of regions as a group	F (7, 566) = 8.46 Prob > F = 0.0000		

Model 2: Kiboga dropped as reference.
Model 3: Luganda dropped as reference.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

contradict the findings above, but may in fact describe two different scenarios. On the one hand a large share of children may mean there are fewer adults with whom the female spouse must share decision-making power. On the other hand, if most of these children are very young, taking care of them will likely mean less time for other activities and therefore less participation in decision-making.

Regarding age, we have included a coefficient for mean age of the head and spouse and age difference between the two. We find that mean age is very significant in all models, with older couples associated with higher levels of empowerment. This may be surprising as it is generally assumed that younger people are more likely to be open to ideas of women's empowerment. On the other hand, an older couple has more "seniority" and, thus decision-making responsibility, some of which is exercised by the female. The age difference between the spouses was not significantly related to empowerment.

Mean education was not a significant variable; however difference in education between the spouses was significant at the 5% level in all models with a negative coefficient. The difference is defined as the male education advantage, calculated as the years of education of the man minus the years of education of the woman. The negative value of the coefficient suggests that the larger the male advantage in education, the lower the woman's empowerment. This implies that raising the general level of education alone may not contribute to women's empowerment, but promoting gender parity in education could.

This is in line with Meier zu Selhausen (2016) results from Uganda, which suggests that a gap in education between spouses negatively influences women's ability to make decisions. Meier zu Selhausen also finds a gap in age negatively related to choice, a relationship that we did not find in our data.

An important variable found significant in each of the models is the travel time to the nearest paved road. The regression results show that the greater the travel time, the lower the level of female empowerment. This implies that women in remote rural areas, far from a paved road, are less likely to be empowered than those living in more accessible areas. This may be due to the exposure to new ideas and ways of life, as well as wider access to information that comes with proximity to urban areas.

Another statistically significant variable included in Model 1 is the share of crop production that is sold, rather than consumed by the household. This variable distinguishes subsistence households from more commercially-oriented households. The relationship to women's empowerment is negative, suggesting that the more subsistence-oriented households have a higher level of female empowerment. A possible explanation is that growing and selling cash-crops is usually the domain of men, so a large share of crop production being sold may be associated with greater control over resources by the husband, tipping the balance of power. This interpretation is supported by the fact that women report significantly less input into decision-making on income from cash-crops than men (41% versus 74%), even when they

have been involved in cash-crop production. However, this result should be interpreted carefully because the marketed share is an endogenous variable, being the outcome of household decisions.

In model 2, we test for geographic variation in women's empowerment by including seven dummy variables representing the eight districts where data were collected. The district of Kiboga in central Uganda, which is the one closest to Kampala, is used as the reference district. Women's empowerment is significantly higher in three districts, namely Masindi, Kiruhura and Ntungamo. Kiruhura and Ntungamo are in southwestern Uganda on the road to Rwanda, while Masindi is in the northwest, near Lake Albert.

To find out whether the geographic patterns can be related to cultural differences affecting women's empowerment, in model 3 we used dummy variables representing languages spoken in the households, as proxies for ethnicity. Eleven different languages are reported to be spoken by the survey households. In the regression model, Luganda, the most-widely spoken language in Uganda, is omitted as the reference. Model 3 finds three languages, namely Acholi/Lango/Luo, Alur and Runyankole/Rukiga, are positively associated with women's empowerment. Acholi and Alur are Nilotic languages spoken in northern Uganda (near Masindi), while Runyankole/Rukiga is a Bantu language spoken in the southwest.

We then conduct Wald tests to evaluate the joint significance of region and language variables, that is, the importance of these variables as a group. We find that the effect of regions and languages are each highly significant. Based on this we can conclude that there are cultural differences that significantly affect the role of women, their decision-making and empowerment, even within a small country such as Uganda. These differences need to be taken into consideration in the design of gender projects in the region.

In Models 2 and 3 owning a phone was a significant variable, positively associated with women's empowerment, although only at the 10% level. Whether this can be seen as a proxy for being modern or if it is somehow related to the regional, or in practice cultural, variables is difficult to say. However, considering the growing numbers of phones in rural areas of Africa and the potential access to information this offers, it is an encouraging result. Several other variables were also tested for significance in different models, but dropped from the final analysis either due to non-significance or because they were problematic for other reasons. One of these was membership in local organizations. We did find that membership in general correlated with high levels of female decision making. However, based on the simple question if an organization exists in the community and whether the respondent is a member, only gives information on nominal membership, but not on the possible benefits it may provide. This is exactly the problem raised by Meier zu Selhausen (2016) and discussed previously in the paper. Secondly, there was confusion in the way organizations were reported. When comparing the responses of individuals in the same household, there was a large disparity between the responses. Either this means the different respondents had different definitions of organizations or they had different knowledge about the existence of local organizations. Due to these issues, we considered the information unreliable and did not include it in our final model. Additional questions, as the ones used by Meier zu Selhausen to identify the factors that influence women's membership in cooperatives, would be required in order to make a useful analysis regarding the implications of participation.

Discussion and conclusions

Women's empowerment is important, both as a human rights objective in itself and as a means to increasing agricultural productivity and improving health and nutrition, and other wellbeing outcomes. Using gender-disaggregated data from Uganda, inspired by the WEAI, this study attempts to identify the most important community, household, and individual characteristics that influence women's empowerment.

Our results confirm that there are significant differences in decision making between men and women in farming households in Uganda. At the same time, it is important to recognize that the division of responsibility is more complex than is sometimes appreciated. For example, men report greater participation in decision regarding cash crops than women, as expected, but this does not mean women are not involved in those decisions: half of all women report being involved in 'all' or 'most' decisions regarding cash crop production, and 42% report participating in 'all' or 'most' decision regarding the spending of income from cash crop production.

This can be understood if we think of "bundles of rights" that are allocated among members, rather than individuals having complete ownership or decision-making power alone. Doss et al. (2014) argue that a single individual rarely holds full ownership or rights, but for example land can be split into rights to access, withdrawal, management, exclusion and alienation. Being part of one of these aspects does not necessarily indicate having power to participate in all important decisions. However, the fact that such a high percentage of women do take part also in the decisions made on spending of income is encouraging. Sharaunga, Mudhara, and Bogale's (2016) study from South Africa showed a strong link between women's participation in financial management and household food security. In a study from Niger, Wouterse (2016) finds that the "greater the share of power held by the female adult, the higher the spending on health (including insurance contributions) and the lower the spending on vices (cigarettes and alcohol)" (p. 12).

We identify several household characteristics that are associated with women's empowerment. The results point to a variety of determinants influencing women's empowerment, suggesting that there are many different individual as well as socio-economic features that are related to empowerment.

Our results confirm that education is an important contributor to women's empowerment, but the relationship is not as straight forward as expected. According to the regression analysis, male educational advantage is associated with lower levels of women's empowerment. This suggests that empowerment is, at least to some extent, associated with education equality. This is in fact a central result, as it challenges the notion that increasing the education of both men and women will in itself empower women. Uganda's universal education campaign has had a significant impact on enrolment in basic education for both girls and boys (World Economic Forum, 2017). However, school enrolment in itself will not solve some of the pressing equality issues, as there is a much higher tendency among girls to drop-out of school (OECD, 2015). Reducing the gap between men's and women's education level should be the target if the goal is to empower women to play a greater role in economic decisions within the household. Therefore, addressing the specific constraints that lead girls to leave school sooner should be a priority. This is highly related to empowerment, as many reasons for girls dropping out of school are related to gender roles and norms (Stoebenau et al., 2014). A commonly quoted reason for adolescent girls to drop out of school is teenage pregnancy. In Uganda, however, poverty is a much more important reason. It affects girls' education more than boys due to gendered beliefs and gendered expectations that force girls to take on a larger burden of household work and helping the family (Stoebenau et al., 2014). The widespread acceptance of such behavioural models and discriminating practices among both men and women hampers progress towards gender equality (OECD, 2015).

The mean age of the spouse was positively associated with the woman's empowerment. We interpret this as being related to the seniority of the couple, which confers greater decision-making responsibility on both spouses. This is also reflected by the mean empowerment score of different household members responding to the individual survey. Both sons and daughters had significantly lower levels of empowerment than the household head or spouse. Age of the woman was the only variable found by Peterman et al. (2015) to be a significant

contributor to female decision-making in Uganda. This is an outcome that reflects cultural value in the community. However, not many policy measures can be designed based on this result. Indirectly, however, increased education may have an impact on changing gender roles. OECD's 2015 study concluded that lower levels of discriminatory attitudes were found among people with higher education.

According to our results, longer travel time to paved roads is strongly associated with lower levels of women's empowerment. These results contrast those of Wouterse (2016) in Niger, who finds that the more accessible the village is the less empowered the female in the household is. Our results are likely due to the fact that people in remote rural areas have less access to information and are less exposed to the values of the educated urban population, where gender equality is more widely accepted. Wouterse (2016) argues that increased economic activity may cause time poverty for women, weakening their empowerment. Our data suggests that the more non-farm economic activity a woman is involved in, the more empowered she is. There are likely different drivers related to these contradictory results, captured by the different studies. In our case empowerment was related to decision-making, and women had a high level of say relating to activities outside the household in which they participated.

We also find some geographic patterns in women's empowerment. Since we suspect these reflect cultural differences, we replaced the district dummy variables with variables representing the languages spoken by members of the household. These variables are considered proxies for ethnic and cultural differences between groups. They provide strong evidence that cultural aspects need to be identified and taken into consideration in any project or intervention that targets women's empowerment.

Conclusions

The results of this study have several implications for efforts to address gender inequity in rural Uganda and similar countries. First, the descriptive analysis of the division of responsibility for economic decisions is more heterogeneous than is sometimes appreciated. As noted above, men are more likely to play a larger role in cash crop decisions, and women are slightly more likely to take a leading role in food crop production, but the pattern is weaker than expected. For example, half of all women in households with cash crops report being involved in most or all production decisions. The implication is that extension agents who focus exclusively on men for cash crop messages will omit a significant number of women who are involved in these decisions. Likewise, agents who deliver advice on growing food crops to women alone will not reach many men involved in these decisions, although this may be a less-common problem. Engaging farmers through improved extension activities, such as Innovation Platforms (Sell, Vihinen, Gabiso, and Lindström, 2018), would allow them to be active participants in identifying challenges and co-creating solutions. Another important mechanism that could be developed to support local productivity and market access is establishing cooperatives (Meier zu Selhausen, 2016).

Second, programs that seek to expand educational opportunities for all children, while building human capital and increasing income-generating capacity of the next generation, may not contribute to reducing gender imbalances and empowering women. Currently enrolment rates for both girls and boys are high in Uganda. However, girls tend to drop out earlier than boys (Stoebenau et al., 2014; OECD, 2015) As our results suggest it is the male-female education gap that influences female empowerment, the reasons for girls being more likely to drop out need to be addressed. Educational programs should focus on achieving gender equity in schooling outcomes.

Third, this study found that female empowerment varies significantly by region and that this seems to reflect language differences, which are presumably a proxy for cultural differences across ethnic groups. This is in line with OECD's country report, suggesting there are reginal variations in social institutions that discriminate against women (OECD, 2015). In addition, we find the female empowerment is significantly and negatively related to travel time to a paved road. These results suggest that it may be possible to use geographic targeting, focusing on specific areas where the challenges are more obvious, to increase the cost-effectiveness of programs to address gender issues.

This study also has implications for future research on gender and decision-making. First, this study focuses on the case of rural Uganda, so an obvious question is whether the patterns observed in this study apply to other African countries or other regions of the world. The growing number of countries where the WEIA has been implemented makes it possible to examine the generalizability of the patterns found in rural Uganda.

Second, although this study identifies a number of factors associated with women's empowerment, including age, male-female educational differences, remoteness, and location, the individual and household characteristics we examine explain barely 13% of the variation in the women's empowerment index. Future research could examine additional variables that may explain women's role in decision-making. Variables which could be considered include assets brought to the marriage, proximity to other family members, characteristics of the respondent's parents and upbringing, and the influence of community norms.

This study focuses on the household and community characteristics than influence women's role in household decisions, representing the left side of the conceptual framework shown in Fig. 2. Another direction for future research is to study the effect of women's empowerment on household outcomes such as income, health, and nutrition. Also, the

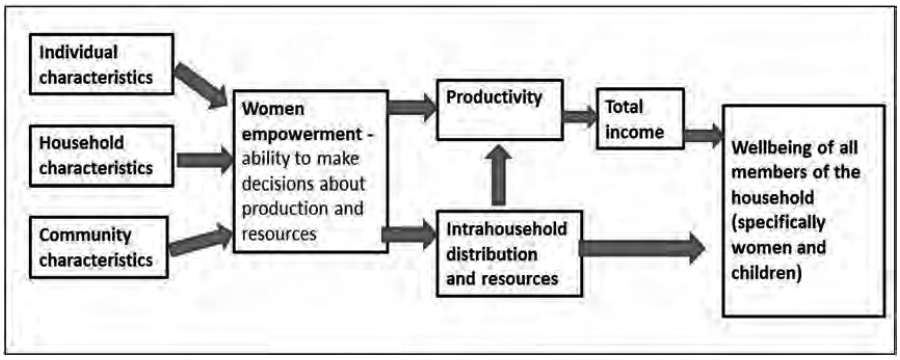

Fig. 2. Conceptual framework of women's empowerment.

level of women's empowerment within different domains may matter. For example, does women's role in decisions about the use of income from different activities matter more than their role in production decisions, as many recent studies seem to indicate? Although the endogeneity issues are challenging, the effort is justified by the importance of the questions.

Finally, this study contributes to the growing number of works that use the Women Empowerment in Agriculture Index. Although we used our own modified version of the WEAI, we got an insight into the new and innovative ways to review data that the methodology provides. When looking at specifically gender related issues through this approach, new linkages between underlying issues can be highlighted and provide important evidence for further studies or policy makers to continue from. Given the importance of women's empowerment as an end in itself, as well as its influence on productivity, nutrition, and human capital investment, further research on the determinants of empowerment are warranted.

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Paper II

Paper II:

The Unequal Efficiency Gap:

Key Factors Influencing Women Farmer's Efficiency in Uganda

The Unequal Efficiency Gap:
Key Factors Influencing Women Farmer's Efficiency in Uganda

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Abstract

There is an assumed gap in efficiency between male and female farmers. Identifying the constraints of women farmers causing the gap is essential for improving local food security and well-being. Using Stochastic Frontier Analysis we compare the efficiency of men, women and jointly managed maize plots in Uganda, and look at factors associated with inefficiency of women. Our results show that the average technical efficiency of women is lower than that of men or jointly managed plots. However, in relation to a group specific frontier, the women are highly efficient. Women's inefficiency is associated with several household features. The overall number of household members has a negative effect on efficiency, suggesting women are time constrained by the efforts they put into household productive work. There also seems to be an association between efficiency and cash-crop farming, disadvantaging women who more commonly grow crops for household consumption.

Key words: Africa; Uganda; small-scale farmers; women farmers; efficiency; stochastic frontier analysis; gender gap

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Public Interest statement

Feeding the world in the future is going to be a major challenge, due to growing populations and the negative impacts of climate change on agriculture. Future food systems will need to be extremely well functioning, starting from effective production systems. In Africa, agriculture is far from reaching its productive potential. There are many reasons for this, but one is that resources are not used as effectively as they could. This seems to be particularly true for women farmers. This is important because women produce much of the locally consumed food and the effect on household wellbeing if they were to improve their efficiency is potentially great. In our study we have tried to identify the gender-specific constraints that influence women's efficiency, including family structure, farming system and access to inputs. We need to understand these underlying reasons in order to work together with local communities to find new solutions that support women.

Introduction

In a world faced with climate change, growing populations, biodiversity loss and various other challenges, it is essential to use existing resources as efficiently as possible. This is especially important in order for people to achieve food security, livelihoods and well-being. Improving current levels of agricultural efficiency is conceivable, as current production systems often do not reach their full potential. In Sub-Saharan Africa many countries face a substantial yield gap as they may achieve only 20 per cent of the potential yields, especially within low-input agriculture (Deininger et al., 2011; Fischer and Shah, 2010). From a developmental perspective this raises concerns, as agriculture accounts for around 30 per cent of the Gross domestic product in East Africa and employs over 70 per cent of the population (Food and Agriculture Organization [FAO]nof the United Nations, 2014). Improving efficiency and productivity of small-scale farmers can have a major impact on food security and livelihoods, while at the same time mitigating climate change. Women are reported to produce only 70-80 per cent, of the yields their male counterparts produce (Aguilar et al, 2015; Ali, et al., 2016; FAO, 2011). This difference is often referred to as the gender gap (Kilic et al., 2013).

For most small-scale farmers increasing yields by expanding the cultivated area is not an option, and therefore increasing productivity is a very relevant alternative. In order to support small-scale farmers to become more productive the most important determinants of technical efficiency need to be identified, especially that of female farmers. It is currently agreed that the difference in productivity between men and women is due to gender-specific constrains, including limited access to resources, as well as cultural or socio-political factors (Aguilar et al., 2015; Peterman et al., 2011).

Stochastic frontier analysis (SFA) can be used to compare the efficiency of different groups, as well as to identify particular factors; individual, household or agronomic, associated with higher or lower level of efficiency.

The aim of this paper is to provide an insight into how gender influences efficiency in Uganda. Our assumption, based on literature on land- and asset ownership, and productivity, is that women farmers are more constrained than male farmers, which negatively affects their efficiency.

The specific objective of this study is to test whether female-managed plots differ from male-managed or jointly managed plots in terms of efficiency. We study the factors associated with efficiency of the female group. Through this we identify some of the most important drivers of the gender gap. The results contribute to the literature by adding to the understanding of issues that impact women farmers' efficiency in Uganda and by comparing the results regarding efficiency of female-managed plots when estimated separately and jointly with male-and jointly managed plot.

Background

Traditionally, information on farming has been collected at the household rather than the individual level, which means many important underlying factors that affect the productivity of women remain unrecognized (Doss, 2014). Even when gender-disaggregated data has been collected, sex of the household head has often been used to define gender differences in productivity, although such an approach leaves out all the women farmers working within male headed households. In addition, the focus has often been simply on input and output, not taking into consideration the effect of the fewer resources or other constraints that the women in a household tend to have (Quisumbing, 1996). Such studies are not particularly helpful, when trying to determine recommendations that could improve women's productivity. Instead, the direct causes of the productivity gap between men and women as well as the underlying reasons, need to be identified, analysed and reflected upon.

Some key factors inhibiting women's productivity have been identified. An important factor is women's lack of official land ownership or tenure documents, which hinders access to credit, and through that, investments in improved inputs and technologies (Combaz, 2013; Doss et al.,

2014). Other factors include lack of access to labour, time constraint, as well as unequal decision-making on household issues (wa Gĩthĩnji et al., 2014; Sell and Minot, 2018). Women also have much less ownership and control over other assets that could potentially enable pathways out of poverty and more stable livelihoods, such as livestock, equipment and resources (Quisumbing et al., 2013).

Another critical challenge, identified by several studies is women's difficulty in accessing markets. The reasons for this may be partly cultural, making women less mobile, but is also due to women generally having smaller quantities to market and less contact to trader networks (Hill and Vigneri, 2009; Combaz, 2013). This has led women to be excluded from contract farming in high-value sectors such as export vegetable markets (wa Gĩthĩnji et al., 2014). In practice this means women have to rely on different strategies than men. It can be said that men produce for the market while women produce for household consumption.

Although these general factors provide a good overview of the challenges faced by women in agriculture, more detailed and context-specific analysis is needed in order to make useful policy recommendations. It is, therefore, encouraging to see that many contributions towards this end have been made recently. Some studies, starting from Kilic et al. (2013), have used decomposition, especially the Oaxaca-Blinder method to better understand the mechanisms and various underlying aspects influencing the productivity gap (Aguilar et al., 2015; Slavchevska, 2015; Ali et al., 2016). These studies split the productivity gap into endowment effects and structural effects, but also for example decompose the productivity distribution into quintiles, to identify the effects at different points of the productivity scale (Aguilar et al., 2016). Although Aguilar et al. find that more than half of the productivity gap is related to structural issues, age and years of schooling are significant effects only at the higher levels of productivity. Factors such as child dependency ratio or women's time burden, related to greater child care responsibility, are factors that negatively affect women's productivity (Slavchevska, 2015; Ali et al. 2016). Surprisingly, Ali et al. conclude that the effect of material inputs,

such as fertilizers and pesticides is insignificant. This is likely due to the extremely low usage among Ugandan farmers in general.

Studies looking specifically at differences in technical efficiency, rather than productivity in general, are less common in the literature. The relationship between gender roles and efficiency is still a neglected research area (Addison et al., 2016). Some targeted case-studies have been conducted (for example Dadzie and Dasmani, 2010; Addison et al., 2016; Dossah and Mohammed, 2016) mostly aimed at identifying the determinants of efficiency of male and female farmers as two separate groups. The methods and variables associated with efficiency vary in the different studies, but most include factors such as family size, age and education of the farmer. In some cases also other factors, such as marital status have been included in the analysis (Simonyan et al., 2011), and commonly also contact with extension agents.

These studies show mixed results regarding women farmer's efficiency. Most find women farmers to be less efficient than men, but some arrive at the opposite outcome (e.g. Oladeebo and Fajuyigbe, 2007; Simonyan et al., 2011). Also the determinants of efficiency vary between these studies. One common determinant associated with higher efficiency, identified by several studies, is level of education. However, contact with extension produced varied results. This suggests context is an important part of inefficiency, and in order to make conclusions and suggestions, familiarity with the particular situation of the farmer group and community is essential.

Measuring efficiency with the stochastic frontier approach

The concepts of efficiency and productivity are sometimes confused, although there is an important distinction between the two. Productivity can be defined as a measure of the amount of output obtained per the amount of input used (for instance, how much maize is produced with a given amount of seed, fertilizer and labour). By contrast, efficiency refers to measuring the actual amount produced when comparison to how much *could* be produced with the same amount of resources (input). Efficiency therefore examines

how much actual output differs from the maximal output with a given set of inputs (Coelli et al., 2005).

The most common method for measuring efficiency is stochastic frontier analysis (SFA). A stochastic approach is suitable for work on agriculture, as agriculture involves a lot of variability. SFA is a parametric method where the frontier function is estimated by using statistical methods. Literature on the stochastic frontier approach originates from the work of Aigner Lovell and Schmidt as well as Meeusen and Van Den Broeck, two groups of researchers who simultaneously came up with the theoretical approach in 1977 (Kumbhakar and Lovell, 2000). SFA models allow for technical inefficiency, but they also recognize that random shocks outside the control of producers, such as weather, luck or variation in machinery performance, affect the output. SFA models try to separate the contribution of random factors from the contribution of variation in technical efficiency. In a stochastic frontier model, the compound error term consists of a two-sided noise component, which is independent and identically distributed and symmetric, and of the non-negative technical inefficiency component, as illustrated in *Equation 3*. below.

SFA requires using quantitative data including information on input quantity. Parametric approaches require the functional form of the frontier to be defined prior to the estimation, by specifying a particular function relating output to input. However, tests to select the best specification exist and are used here prior to selecting the final model. Robust efficiency estimations require the method to allow for random shocks as well as measurement errors which may occur in field data. The data also need to be sufficiently large and robust. Our data include information collected from 1400 farms.

The production functions most commonly used in SFA are Cobb-Douglas, quadratic or the translog function. They are linear in parameters and can be estimated using least squares methods that allow multi-output and multi-input distance functions. The advantage of the Cobb-Douglas function is its simplicity, however, it is less flexible than the models including second order- and cross-terms. The alternative functional forms can be tested against each other through a nested test. Choosing the right model should be based

on the data and on the model providing the best fit, as well as on the focus of the study, as different models may give slightly different results (Kuosmanen et al., 2013).

An alternative approach to assess efficiency of a decision making unit would have been Data envelopment analysis (DEA), which is suitable for analysing cross-sectional data particularly in smaller datasets. In a non-parametric approach such as DEA there is no need to specify the functional form of the frontier as it is determined by the most efficient producers. However, the best specification cannot be tested and the number of efficient firms on the frontier tends to increase with the number of inputs and output variables (Berg, 2010). Non-parametric approaches have the advantage of low specification error, but they do not allow for measurement error or random shocks. As these factors are attributed to (in)efficiency, this leads to potential estimation errors.

Efficiency is estimated using a production function that usually incorporates a model for assessing the factors influencing the inefficiency. This can be done in two steps or a single step approach. In the two-step approach the efficiency scores from the first stage are regressed on a set of variables that are asumed to influence efficiency, while in the case of the single step procedure, the estimation of efficiency and the factors influencing efficiency are done simultaneously. The two-step model has been criticized for its inconsistency relating to the assumptions regarding the independence of the error component (Battese and Coelli, 1995). Although there are ways around this inconsistency (Madau, 2011), most scientists rely on the single-step approach developed by Battese and Coelli (1995).

Battese and Coelli, agree that there is no formal econometric model to describe technical efficiency (Battese and Coelli, 1995; Battese et al., 1996). It will be up to each scientist to make an informed choice on which parameters will be relevant for the specific research question. This implies a certain degree of arbitrariness in the definition of the inefficiency effect variables (Irz and Thirtle, 2004). This also provides the opportunity to create a number of behavioural variables relating to issues such as farmers' goals and preferences and analyse how these affect efficiency (Berkhout et al., 2010). Depending

on the available data and the focus of the study, the variables to explain efficiency may include issues such as family size, number of working adults, education or experience of family members, area of cultivated land and land quality, land tenancy, share of non-agricultural income, extension contact, to name a few.

Data and Methods

Our data are from a household survey conducted in Uganda in collaboration with International Food Policy Research Institute (IFPRI), as part of the Finnish funded FoodAfrica Programme (2012-2018). Uganda has a predominantly rural population (72 %), relying heavily on agriculture for their livelihoods (Uganda Bureau of Statistics [UBOS], 2014). There are different climatic zones in the country, which means the varying conditions are factors influencing productivity. The climate is generally stable and mostly suitable for agriculture even though climate change is predicted to have severe impact on productivity over time (James, 2010). We have chosen to focus on one of the most central crops in Ugandan agriculture, namely maize. Maize is one of the most important staple crops in Uganda, together with matoke (cooking banana), cassava and beans. Studies show that maize yields in Uganda will be severely impacted by climate change, reducing yields by five per cent by 2050, compared to yields in 2000 (Kikoyo and Norbert, 2016). Identifying ways to increase production is therefore essential. Maize is also interesting as it is a central crop in East Africa, grown by a large majority of households. Comparisons to other African countries may therefore be possible.

As part of the study in Uganda, a baseline household survey was conducted in December 2012 to January 2013, in eight districts of the country as shown in the map in Figure 1.

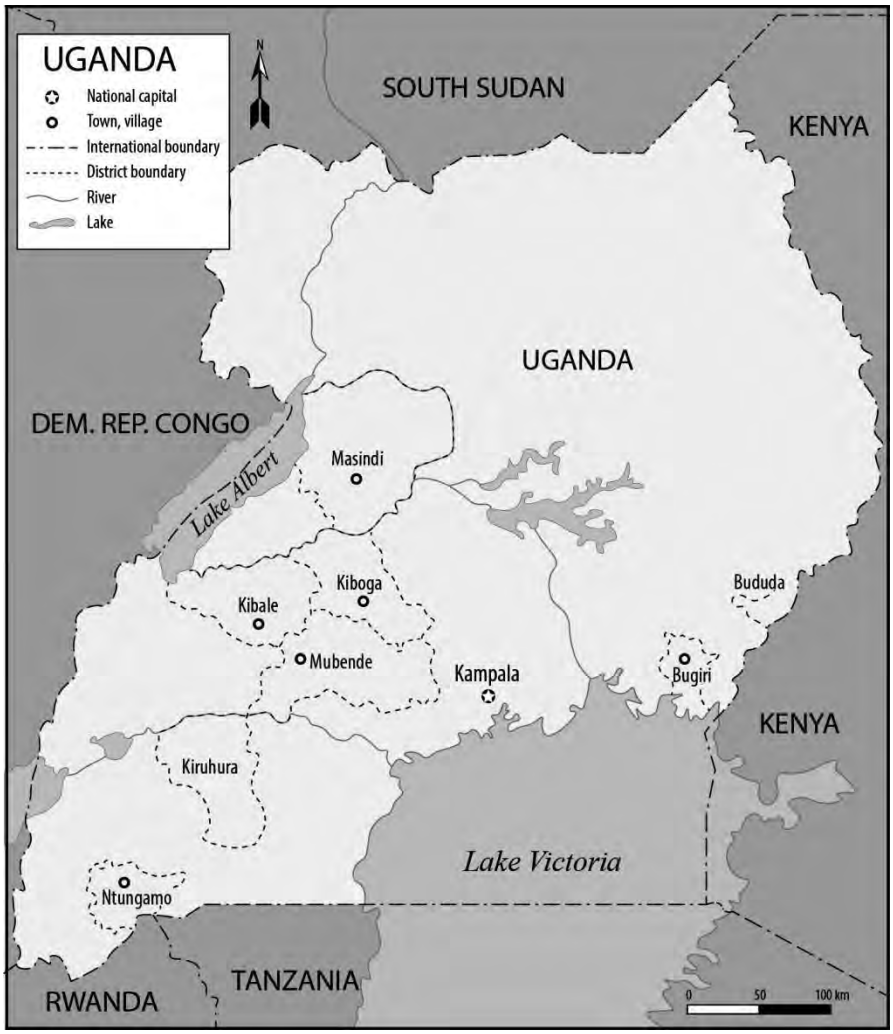

Figure 1. Map of Uganda highlighting study Districts (©Magdalena Lindberg)

The survey covered approximately 1400 households and generated a large amount of information on households' production systems. After deleting observations with missing values and outliers, we ended up with 896 observations of maize-growing households for the efficiency analysis.

The data were sex-disaggregated, specifying if the plot was managed by male farmers, female farmers or jointly. The way management was defined in this study is in line with other studies with similar objective, (for example Aguilar et al., 2015). For management the enumerator manual stated: "Ask who in the household has primary responsibility for the decisions related to

the production of the crop in this plot in this season". The management responsibility was coded either to the individual person or as jointly managed. The focus was on decision making and it does not necessarily imply actual labour use by the responsible person on the plot in question. As the data did not include information on the amount of household labour allocated to specific plots, we could not determine a traditional production function.

However, the data did allow comparison of output, in relation to input, including land, seed, fertilizer and pesticides, by the different management systems. In addition, the survey data included a range of variables that describe both the household and the individuals in the household, such as age, educational level, and possible non-farm activity. Household characteristics included number of household members, the crops grown and the share of the yield sold in the market, as well as other assets owned by the households, such as animals. This gave us an overview of a typical small-scale farming household in rural Uganda and allowed us to identify the most important constraints for women farmers.

The survey also included a time-use module, based on the women empowerment in Agriculture index (WEAI). Both a female and a male household member responded to a 24-hour recall study, reporting what he or she had done as primary and secondary activity for each hour between four in the morning the previous day until four in the morning of the survey.

It was not possible to integrate this information directly into the production function as it was based on a 24-hour recall. However, it gave us useful background information on the differences in time-use of men and women in the study. In Table 1 the mean hours used by men and women for key activities are reported, grouped into five categories. The most significant difference can be seen in relation to domestic work. Women use on average close to five hours doing domestic work, while men use on average only one and half hours. The amount of sleep of men and women are very similar. Women use slightly less time than men on all other activities apart from sleep or domestic work, including agricultural work, other employment or leisure. However, no other category has such a large difference between men and women, as does domestic work.

Table 1. Time-use among male and female household members

Activity (24h recall)	Male h	Female h
Sleep	11,12	11,22
School/Employment/Business*	1,58	0,64
Agricultural Work	3,93	2,64
Domestic Work**	1,56	4,99
Leisure***	5,82	4,52

*School, employment and business includes going to school or doing homework, working as employed of engaged in one's own business work.
**Domestic work includes cooking, caring for children, adults or elderly, domestic work, such as cleaning and fetching wood, also activities such as shopping and getting services, including health series and weaving, sewing and other textile work.
***Leisure includes such activities as watching tv, listening to radio or reading, exercising, social- and religious activities, others.

Conceptual Framework and Empirical Specification

Based on the literature, our hypothesis is that female-managed plots are less productive and one of the reasons for this is lower efficiency of female farmers. We, therefore, test the difference in efficiency between the groups and identify the causes of inefficiency. We are interested in whether the major determinants of efficiency are related to inputs, human capital such as education, or other individual, household or community related factors, and whether these differences are attributed to gender inequalities related to access or perhaps other structural and institutional causes?

Maize is widely grown by all groups, that is by women, by men and on jointly managed plots. However, within the household it is not common to grow maize under different management types, even when grown on several plots. Only seven per cent report different management types for maize plots. We can therefore use a household as our unit of analysis, but not to make inference about intra-household distributions or difference in efficiency.

The data provide information on inputs at the crop, rather than the plot level. For the sake of the analysis we have included the small group of households with maize under several management types in the joint

management group, leaving us with three distinct management types to compare. We utilize Battese's and Coelli's (1995) single step approach to Stochastic Frontier Modelling, estimating the parameters associated with technical efficiency. This is based on a production function where we look at yield, that is, output per hectare, and inputs including land, seed, and equipment, as well as their quadratic terms. The use of fertilizers and pesticides has been combined into a chemical inputs dummy variable, which is also included in the production function.

We have not included labour in our production function, because the data do not include information on household working hours allocated to specific plots. Because the majority of the respondents were small-scale farm households, using hired labour was uncommon. Overall any form of hired labour was used only for 15 per cent of plots. Hired labour used specifically for maize was higher, 33 per cent, however, even for those using hired labour it was usually only for a few working hours, which means it has no impact for the model.

Information on household labour was included in the data through the specification of main and secondary activity of each household member, as well as through the 24-hour recall time-use model, as described above. Because farms are often small and family labour has a very low opportunity cost, there is evidence that household labour is often overused (Oladeebo and Fajuyigbe, 2007). In rural areas, people also face disguised unemployment, which leads family members to participate in farm work as little opportunity for off-farm work is available (Coelli et al., 2002).

The stochastic frontier function used in the study is defined as:

Equation 1. $Y_i = f(X_i;\beta)\exp(\varepsilon_i) = f(X_i;\beta)\exp(V_i - U_i)\,, i = 1,2 \ldots . N$

where Y_i is the log of output in kg per hectare for the i^{th} farm, $f(X_i;\beta)$ is the production function, X_i is a vector of inputs in a logarithm-transformed form and ε_i the error term. The error term is a two way error component, where V_i is random error and U_i is management-related efficiency component. V_i is assumed to be independently N(0,σ_v) distributed. U_i is assumed to be

independently half-normal, and takes values between zero and one, where one indicates full efficiency.

Empirically our model is presented as:

Equation 2. $lny_i = \beta_0 + \sum_{k=1}^{m} \beta_k lnx_{ki} + \frac{1}{2}\sum_{k=1}^{m}\sum_{j=1}^{m} \beta_{kj} lnx_{kji} + v_i - u_i$

where ln is the natural logarithm and y_i output measured in kg per hectare, x_{kj} , is the vector of input variables for *k* different parameters, including land area, seed and their quadratic terms, based on the quadratic function, β_k are the vectors of parameters to be estimated, u_i is vector of random error and u is a vector of management-related efficiency component.

We include the following Battese and Coelli (1995) model specifying the inefficiency effect:

Equation 3. $\mu_i = \delta_0 + Z_i\delta_i$

where Z_i is a vector of explanatory variables associated with technical efficiency effects, δ are vectors of unknown parameters.

All variables were normalized before calculating the logarithms.

Information on all household assets and numbers owned at the time of the survey was collected. The variable representing agricultural assets is calculated as the sum of the value of each asset. The value used is the price of a new item in 2012, because the exact current value of each asset was unavailable. For the seed variable we have not differentiated between the source of seed used by the household, which in the collected data is separated into bought, saved and donated. The input variable for seed combines all seed use into one value which is expressed in kilograms rather than in monetary value.

The inefficiency effect is a vector of both household and individual level characteristics. The vector includes household size and number of members in different age groups, location of farm in terms of distance to

paved road, describing how remote a given household is, and the share of the yield that is sold on the market.

Individual information includes age and years of education of the household head and spouse as well as participating in non-farm income generating activity. Age is often used as a proxy for experience, although the literature is mixed on whether it influences technical efficiency in a positive or a negative way (Rahman, 2010). We consider all three individual variables to be relevant in terms of experience and likely to influence efficiency.

In addition to the household and individual vectors we include the study districts as dummy variables. Data were collected in all of the eight districts seen in the map (Figure 1). However, the number of observations in some districts was quite limited, so we have combined the district of Bugiri and Bududa into a variable called *East*, and the districts of Kiruhura and Ntungamo into a variable called *Southwest*.

Our production function describes the yield in quantity. In the context of our data, this is more intuitive than using the value of output as only small shares of the yield are sold. Similarly, seeds are measured in quantity as substantial proportion of seed originates from the household's previous harvest or are acquired as donated seed.

Model specification

Several specifications of equations and models were estimated to identify the best fit for the data at hand. In order to select the best-fitting functional form log-likelihood ratio test, utilising chi-square values[1], was used to test the Cobb-Douglas, quadratic and translog forms. In all of the models, we assume a half-normal distribution of the error term. We found that the quadratic form was the most-suited model for our data, both for specification of the overall model and the female model. The test results indicated that the quadratic

[1] The model used for the log likelihood ratio test is: LR = -2*{log[likelihood (H_0)] – log[likelihood (H_1)]} (Battese, & Coelli, 1995)

model performed significantly better at 5 percent risk level than translog specification. Based on this result we implemented both models using the quadratic functional form.

To evaluate the joint effect of the district variables we ran our models with and without the districts and then tested the results with the likelihood ratio test. The test result for the joint effect of the districts, suggest the model including the districts performed significantly better at the 5 percent risk level compared to the model without districts in our joint model. However, for the female model the districts are not significant even at the 5 per cent level, and therefore not included.

We use Stata 14 for all our estimations.

Results

Descriptive statistics

After the largest one per cent of farms was dropped from the sample as outliers, the mean farm size is 2.2 hectares. The largest outlier farm was 606 hectares, which was not considered representative of the farmers in the area. Eighty-seven per cent of households allocate less than one hectare to maize production. The mean size of male-managed plots was 0.605 ha, while for jointly managed it was 0.468 and for female-managed plots It was only 0.293 ha (Table 2). Among the study households 77 per cent grew maize, 84 beans, 68 matoke and 60 cassava. The largest share of land was allocated to maize, on average 28 per cent of all household land, compared to 18 for beans, 15 for cassava and 17 per cent for matoke.

Table 2. Descriptive statistics of survey data

Management type	Male managed N=268 Mean (SD)	Female managed N=260 Mean (SD)	Jointly managed N=368 Mean (SD)
Ha of land allocated to maize	0.577 (0.687)	0.235 (0.31)	0.477 (0.587)
Kg of input seed/Ha	51.9 (67.4)	60.5 (78.9)	57.1 (79)
Number of household members	6.2 (3.0)	6.4 (3.0)	6.7 (2.8)
Members 5 years and under	1.3 (1.1)	1.1 (1.2)	1.5 (1.2)
Members 6-15 years	2.1 (1.9)	2.3 (1.7	2.2 (1.9)
Members 16-19 years	0.6 (0.7)	0.6 (0.8)	0.6 (0.8)
Member 20-60 years	2.1 (1.1)	2.1 (1.3)	2.2 (1.0)
Members over 60 years	0.2 (0.5)	0.2 (0.5)	0.2 (0.5)
Education in years of highest educated female in household	6.1 (3.1)	6.5 (3.4)	5.8 (3.3)
Age of head of household	42 (15)	48 (14)	43 (16)
Education in years of head of household	5.7 (3.3)	4.9 (4)	5.7 (3.4)
% of household heads involved in non-farm activity	38	42	38
% of household spouses involved in non-farm activity	9	9	6
Mean time in minutes to paved road	86 (148)	71 (204)	71 (181)
% of households in Kiboga District under different management types	44	29	27
% of households in Mubende District	44	23	34
% of households in South-west Uganda	22	60	19
% of households in East Uganda	26	27	47
% of households in Kibaale District	31	24	46
% of households in Masindi District	22	18	60
% of households using agrochemicals	28	10	18
Mean marketed percentage of yield	49 (28)	32/27)	43/28)

Source: Data from IFPRI Household Survey 2012/13

Most farms in Uganda are small-scale, and use very little inputs. Apart from plot size, there are few significant differences in characteristics between households where maize plots are managed by men, women or jointly. There seems to be a difference between districts in which proportion of maize plots are under each management type. In most areas the distribution is quite even, but some stand out. In South-west Uganda sixty per cent of the maize plots in our data are managed by women whereas in Masindi sixty percent were managed jointly. Masindi is also the only district that is significantly associated with higher levels of efficiency, according to the overall model (Model 1. Explained in more detail below). There was insufficient data on other cultural factors of the different districts, to make deeper inference on the reasons behind this.

Only 19 per cent of households used agrochemicals (either fertilizer or pesticides) on their maize plots. Only minor differences between the groups using and not using chemicals were noticed. On average, female farmers were using less agrochemicals than male farmers, as shown in Table 3. Only 10 per cent of all female-managed plots used agrochemicals, compared to 28 per cent of male-managed plots. Out of all plots using agrochemicals, 44 per cent were male managed, 40 per cent jointly managed, while only 16 per cent were female managed, suggesting a gender gap.

Table 3. Use of fertilisers and pesticides under different management types

Management	Use of Agrochemicals NO	Use of Agrochemicals YES	Total
Male	193	75	268
	72%	28%	100%
Female	234	26	260
	90%	10%	100%
Joint	303	65	368
	82%	18%	100%
Total	773	181	954
	81%	19%	100%

S
ource: Data from IFPRI Household Survey 2012/13

Although agrochemicals were not found to be statistically significant as an explanatory variable for technical efficiency, we included it as a dummy variable in the production function. In the overall model it was significantly associated with increased yield, but had no significant effect in the female model. This could be an indication that supports Aguilar's et al. assumptions regarding future developments. However, considering the very low number of users among the female group no such conclusions can be made.

Stochastic Frontier Analysis

We start the analysis by running a quadratic model of the whole data to identify the most important factors related to efficiency (Model 1). Management type was included as explanatory variable, leaving out female management as the reference. The analysis shows that both male management and joint management stand out as very significantly associated with higher efficiency, compared to female management. This is the most important factor influencing efficiency in our model. The age of the head of household is also associated with lower efficiency, but only at the 10% risk level.

The share of the yield sold by the household, rather than used for own consumption, was a variable significant at the 1 per cent level. However, again the actual effect on the coefficient was very low. A statistically significant relationship was found between a higher efficiency on the plots and the spouse of the household (in 98% of cases a female) being involved in income-generating activity outside of the farm household. This may suggest that providing women with off-farm opportunities for income-generating activity may have positive effects on the farm household. This is in line with the literature, according to which personal access to income improves women's empowerment, and thereby household wellbeing outcomes, such as child nutrition (Sraboni et al., 2014; Wouterse, 2016). Therefore, it is an interesting result to explore further in future studies. Share of crop yield sold was another variable significantly associated with higher efficiency, both for the overall and for the female model, although the significance level is much

higher for the overall model. This suggests that commercial plots are managed more efficiently.

Farms located in Masindi district achieved higher levels of efficiency than farms in other areas. There are differences between districts, in relation to climatic and cultural factors. Future studies or programmes should take geographical and cultural factors into consideration in the design-phase. Although there was a difference in the mean size of plots managed by men, by women and jointly, women having much smaller plots, we didn't see evidence on the inverse-effect on efficiency (Table 4.), presented in the literature (see e.g. Slavchevska, 2015; Ali et al. 2016). We also tested including self-reported soil quality dummy variables in the model. In contrast to our expectations soil quality was not found to be significantly associated with efficiency, and was therefore left out of the final model. Possibly this is due to self-reported information being too subjective and thus not reliable.

After confirming our assumption that efficiency of female managed plots was significantly lower than that of the other management styles, we continued to identify the specific factors associated with efficiency of the female group (Model 2). Several variables found to be significant in this model were related to household composition. Increased number of household members was associated with lower efficiency. Women tend to carry the brunt of the burden of household work, including childcare, cooking and in many cases producing food for home consumption in small-scale household gardens. This workload seems to influence the efficiency of production negatively. As the results suggest, the larger the family, the greater the time burden.

The number of older children, aged six to 15 was however associated with higher efficiency. This was interpreted to suggest that older children provide labour input on the plots, thereby helping to improve efficiency. Also time to weekly market and share of yield sold are significant variables in the female model. However, the effect of these variables was considered low, so not much inference can be made based on this.

Table 4. Estimated parameters (z-value) of Stochastic Frontier Models for the 1. Overall and 2. Female Model

		Overall Model	Female Model
lnyieldKgHa	Ln of area	0.062	0.077
		(1.76)*	(0.70)
	Ln of area squared	0.041	0.016
		(2.27)**	(0.33)
	Ln of seed, Kg/Ha	0.399	0.431
		(10.48)***	(5.76)***
	Ln of seed Kg/Ha squared	-0.012	-0.050
		(0.64)	(1.40)
	Ln of value of equipment	0.059	-0.015
		(2.47)**	(0.26)
	Ln of value of equipment squared	0.002	-0.001
		(1.23)	(0.21)
	Chemical Input (dummy variable,1=true)	0.149	-0.036
		(2.03)**	(0.20)
	Intercept	0.645	-0.273
		(8.07)***	(2.00)**
lnsig2v	Intercept	-1.159	-0.297
		(8.09)***	(3.21)***
lnsig2u	Male management (dummy variable, 1=true)	-0.538	-
		(3.08)***	-
	Joint management (dummy variable, 1=true)	-0.469	-
		(2.79)***	-
	Household size (persons)	-0.044	0.664
		(0.70)	(2.23)**
	Number of members 5 years and under	-0.025	-1.045
		(0.26)	(1.54)
	Number of members 6-15 years old	0.044	-1.189
		(0.61)	(2.45)**
	Number of members 16-19 years old	0.117	-0.667
		(1.10)	(1.11)

Number of members over 60 years	-0.035	-3.883
	(0.21)	-
Age of head (years)	0.012	-
	(1.95)*	-
Highest level of education of household member	-0.028	-
	(1.15)	(0.85)
Highest education level in years of female in household	-	-0.082
	-	(0.67)
Head involved in non-farm activity (dummy variable, 1=true)	0.117	-0.468
	(0.80)	(0.50)
Spouse involved in non-farm activity (dummy variable, 1=true)	-0.572	-
	(2.02)**	-
Time to weekly market, hours	0.000	0.021
	(1.02)	(2.32)**
Share of crop yield sold (%)	-0.014	-0.089
	(5.24)***	(1.87)*
East (dummy variable,1=true)	0.213	-
	(0.93)	-
Southwest (dummy variable,1=true)	0.323	-
	(1.25)	-
Mubende (dummy variable,1=true)	-0.129	-
	(0.50)	-
Kibaale (dummy variable,1=true)	-0.210	-
	(0.78)	-
Masindi (dummy variable,1=true)	-0.844	-
	(2.96)***	-
Intercept (dummy variable,1=true)	0.804	-1.406
	(1.88)*	(1.00)
N	896	259

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Source: Data from IFPRI Household Survey 2012/13

Elasticities

We calculated the input elasticities for the overall model and for the female model. There are no clear differences between the groups, as can be seen in Table 5. For both models seed is the input with the highest elasticity (0.38 for the overall model and 0.33 for the female model). The elasticity suggests that for the female model if you increase the seed input by 1%, maize output will increase by 0.3 %. Area elasticity has the value of 0,11 (female model) and 0.15 (overall model), which implies that increasing land area by 1%, maize output increases by only 0,11% for female managed farms.

Table 5. Input Elasticities

Overall model	Elasticity
Area	0,15
Seed	0,38
Equipment	0,06
Female model	**Elasticity**
Area	0,11
Seed	0,33
Equipment	-0,15

Source: Data from IFPRI Household Survey 2012/13

Efficiency scores of the different groups

To get a better understanding of the levels of efficiency we calculate the technical efficiency (TE) for each observation. The TE represents the distance of a given observation from the potential maximum, that is, the frontier, and has a value between zero and one, one indicating perfect efficiency. For Model 1, the overall model, the frontier is predicted based on the full data. We calculated the technical efficiency of the different groups, in relation to this frontier, and find that there are significant differences, the mean TE of the male group being the highest.

Table 6. Mean technical efficiency of different management types.

Management	N	Mean	SD	Min	Max
Male	268	0.57	0.18	0.03	0.87
Female	260	0.43	0.21	0.02	0.82
Joint	368	0.56	0.19	0.06	0.84
All	896	0.52	0.20	0.02	0.87

Source: Data from IFPRI Household Survey 2012/13

We group the efficiencies into five categorise, based on the scores, ranging from lowest efficiency, 0.0 – 0.2, up to highest efficiency, 0.81 – 1.0 (Table 7). Around 50 per cent of male and jointly manage plots reach the two highest efficiency categories (although only five per cent respectively is actually in the highest score group) whereas over 70 per cent of women are in the three lowest categories.

Table 7. Number (N) and Proportion (%) of Farmers in each Technical Efficiency Category According to Management type (actual values of technical efficiency)

Efficiency category	Male		Female		Joint	
	N	%	N	%	N	%
Lowest efficiency	10	4	47	18	24	7
2nd efficiency	37	14	71	27	52	14
3rd efficiency	84	31	73	28	99	27
4th efficiency	124	46	65	25	178	48
Highest Efficiency	13	5	4	2	15	4
TOTAL	268	100	260	100	368	100

Source: Data from IFPRI Household Survey 2012/13

However, when the TE is calculated separately for the female model alone, we find that women are in fact very efficient in relation to their own frontier. In this model, 81 per cent of the women reach the highest efficiency category, while only one per cent is in the lowest category. Mean

TE of women in this model is 0.88 (standard deviation 0.16, min. 0.1, max 0.999). This suggest women have the capacity to be efficient within their boundary conditions.

Table 8. Technical Efficiency of women managed plots in relation to own frontier (Model 2.)

Efficiency category	N	%
Lowest efficiency	2	1
2nd efficiency	5	2
3rd efficiency	9	3
4th efficiency	33	13
Highest efficiency	211	81
TOTAL	260	100

Source: Data from IFPRI Household Survey 2012/13

Discussion and Conclusion

In this paper we looked at whether a difference in efficiency in maize production on plots managed by men, women or jointly, can be found. We tried to identify the factors associated with efficiency, both in general and on female managed plots specifically. We used Stochastic Frontier Analysis to analyse the determinants of efficiency. Each model predicts a frontier based on the input and output data of the group and identifies which efficiency parameters are significantly associated with higher or lower levels of efficiency. Each individual observation is then given a predicted technical efficiency score between 0 and 1 in relation to the frontier.

When looking at the overall model we find a significant difference between the technical efficiency of female-managed plots in comparison to that of male or jointly managed plots, the male being the most efficient. However, looking at the efficiency scores of only the female group, in relation to their own frontier, we found on average even higher efficiency scores than those of the men in the overall model. Over 80 per cent were in the highest efficiency category, between 0.8 and 1. This suggests that there are underlying factors negatively affecting the efficiency of women.

When looking at the determinants of efficiency, women were faced with gender-specific constraints. For the female managed plots, we identified household-level factors associated with inefficiency. The most important variables were related to household size and composition. A high number of household members was associated with lower efficiency, suggesting time-burden is a constraint for women. Women commonly allocate more of their time towards taking care of other family members, including housework, cooking and other household activates, at the expense of working efficiently on their own plots. This is in line with other studies, which have found that women in Africa contribute time towards domestic work to a much higher degree than their male counterparts, already at a very young age (Addison et al., 2016). For example Slavchevska found that time burden relating to child care responsibility negatively affected women's productivity (2015). These constraints also limit women's access to other economic opportunities outside the household.

The data used for the analysis are cross-sectional. The results show that women are very efficient in their group, but are faced with gender-specific constraints that reduce their efficiency indirectly. The results suggest that the joint model may not be able to fully identify all characteristics, such as differences in land quality, which may be associated with female-farmers and which may influence their efficiency indirectly. In other words, in the joint group the efficiency of female-farmers may be limited by household-related constraints and (the quality of) inputs that they have at their disposal. Our results show efficiency is higher if the household produces higher shares for the market. Women tend to have smaller plots, use fewer inputs and are less likely than men to produce for the market (Hill and Vigneri, 2009). This reinforces the gap in access to markets, between men and women. Although overall efficiency is not directly affected by issues such as access to markets, some factors may still be important. The results suggest women's efficiency could be improved if they were more market-oriented. However, the fact that women are more limited by their household burden, will likely affect their readiness to do so.

At the same time the overall model suggested that female spouses involved in income-generating activity outside the household was a factor that positively influenced efficiency. Policies to support women's involvement in non-farm income-generating activity may therefore be relevant as an alternative, or in addition to, supporting their active involvement in market-oriented agriculture.

Interestingly education was not significantly correlated with efficiency. This may confirm what Aguilar et al. found in their study, suggesting that education was only relevant at higher levels of productivity (Aguilar et al., 2015). For small-scale farmers with only marginal yields sold to market, even higher levels of education may not significantly help them to improve their efficiency, due to the many other constraints they are faced with.

There are regional variations influencing efficiency, related either to cultural or possibly climatic factors. Therefore support-mechanisms need to be developed that take the specific needs of women in their given contexts and reality into consideration. These mechanisms may include factors that decrease women's time burden within the household and improves their access to resources. It would for example be useful to study the influence of extension and other forms of informal training on the efficiency of women, although previous studies have not always found access to extension associated with increased efficiency (Muoh et al., 2016).

The fact that agrochemicals was not found to be significantly associated with technical efficiency, is in line with findings of Aguilar et al. (2015). They, however argue that if and when the use of agrochemicals starts to increase, it may lead to the productivity gap between men and women increasing again. The gender-effects of any intervention promoting agrochemical use need to be carefully considered.

Based on our study it seems that in most cases women are unable to fill their full potential and may not be contributing to productivity as much as they could. Many of the reasons behind this are linked to structural issues. However, also local issues relating to women's access can play a role in improving the situation. Finding ways of developing livelihood opportunities

for women is central. One step is empowering women to take a more active role, whether as farmers or in other income generating activities. This should therefore be a central policy goal.

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Paper III

Paper III:

Innovation platforms:

a tool to enhance small-scale farmer potential through co-creation

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Innovation platforms: a tool to enhance small-scale farmer potential through co-creation

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ABSTRACT
This article describes the process and analyses the results of a project in Ethiopia establishing an innovation platform (IP) as a tool for co-creation from an innovation systems perspective. The results are encouraging, suggesting positive effects both on yields, but more importantly on the capacity and role of participants as communicators and agents of change in the community. The IP seems promising in creating new networks and modes of communication. The importance of good facilitation, commitment by all members from the start, and feedback loops driving the process was found to be essential.

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Introduction

As a global community, we are faced with a wide range of challenges in the coming decades, caused by climate change, resource scarcity and population growth. For those of us working in the agriculture and food sector, this will require new approaches, methods and technologies. In sub-Saharan Africa, where economies are dominated by small-scale farming, engaging up to 80% of the population, farmers both create livelihoods and contribute to local food security. Therefore, their role is crucial when developing sustainable local food systems, in which both humans and the environment can thrive.

Actively involving small-scale farmers in the innovation process will bring forth solutions that are most suitable in the local context, both in terms of the farming system and in reflecting the direction in which the local community wants to develop. Taking a holistic innovations systems perspective opens up possibilities to understand not only technological innovation, but innovations relating to food systems, markets, incentives, as well as local dynamics and power structures affecting these. This has the potential to create sustainable opportunities for smallholder farmers and pathways toward ecologically and socially just societies, in which women's roles and agency is recognised as assets.

Using innovation platforms (IPs) has become a popular approach to engage smallholder farmers (Davies et al. 2016). Considering IPs as a methodology or tool in agricultural development and research, the operationalisation of the approach is essential. Recent attempts to analyse challenges, best practices and ways to evaluate the efficiency of IPs have been useful, but more insights into practice are called for (Cadilhon 2013; Davies et al. 2016).

This article aims to present structured empirical experiences and an analysis of the strengths and challenges of IP as a tool to introduce new technology through a participatory process. In addition, we will discuss IP's potential as an iterative learning process.

We specifically look at *how the IP methodology was received in the given context, by the local community, both those participating in the IP and among other community members* (question 1). We then look at *the main strengths and challenges in implementing an IP, based on the experiences of this*

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participatory project (question 2). Finally, we discuss *how the methodology could be developed further in order to better serve the needs of all stakeholders* (question 3). This will entail integrating an end-user/co-creation perspective into the process, which may require changing the mindset of some participants (particularly extension agents). The analysis recognises the important role played by existing unofficial networks and looks at the dynamics between the group formed through the IP activity and these networks.

Our work is based on an empirical study in Ethiopia, in which an IP was established with local farmers and other stakeholders to test and integrate new technologies in the farming system. In this context, we also look at women's roles in the innovation processes as agents of change and discuss the possible influence on the role of women who participated in the IP. The data collected are mostly qualitative and context-specific; however, we frame our discussion so that it contributes knowledge and practical solutions that can be useful for the design of future projects as well as for policy-making.

Background

Seventy percent of people faced with persistent poverty live in rural areas, most of them smallholder farmers (Röling 2010). They farm large parts of the arable land in developing countries, mostly through rain-fed agriculture. Supporting them to increase their productivity can potentially have a great impact on their own well-being, but it can also play a significant role in tackling some of the challenges of global food security, such as availability and access to nutritious food from local sources. Although small-scale farmers are in a key position as both producers and consumers in the food system, they also represent the most vulnerable groups, constrained by poverty, limitations in inputs, education and market access. This is especially true for women farmers, who are often even more constrained than their male counterparts, in terms of access, landownership and empowerment.

Institutional conditions have a central role to play as many of the constraints small-scale farmers are faced with are in fact not technical, but rather related to institutional pre-requisites (Adjei-Nsiah et al. 2013). This can mean lack of infrastructure, markets and access to inputs and extension services or it can be related to land ownership and the local tenure systems. State-driven enabling conditions, such as fair prices, the absence of corruption, strong farmer organisations, and regulatory frameworks that countervail exploitative practices, need to exist in order for development to take off. This has been lacking in Africa, and it is one reason why replicating the Asian green revolution wasn't possible (Adjei-Nsiah et al. 2013; Hounkonnou et al. 2012).

Ethiopia is a country faced with many challenges. It is one of the poorest countries in the world, although large improvements have been made in terms of poverty reduction during the past 20 years. Agriculture represents 41% of the country's gross domestic product making it the main source of income, employing over 80% of the nearly 100 million population directly or indirectly (World Bank 2017). However, rural poverty remains high with diminishing farm sizes. In addition, agricultural productivity is inhibited by degraded ecosystems impeding productivity growth, causing food insecurity (Getnet et al. 2017). Agricultural soils are low in organic matter, affected by soil erosion and nutrient depletion. Fertiliser is used much below the recommended level and generally only for the major crops, such as teff, wheat and maize (Getnet et al. 2017).

The Ethiopian government has attempted to target these challenges through the Ethiopian Agricultural Transformation Agency (ATA), initiating a number of new programmes to enhance technology delivery and uptake. It is widely recognised that agricultural advisory services need to be re-conceptualised as the complexity of knowledge production is better understood. Ethiopia has been a forerunner in Africa, making major investments in agricultural extension in an active effort to increase the productivity of small-scale farmers, since the early 2000s (Krishnan and Patnam 2013). One of the new methods introduced through the local governance sub-administration structure is the so-called one to five networks, where a trained farmer is responsible for sharing the new

knowledge with a set group of five other farmers (Bekele et al. 2016). The system is designed to enhance collaboration, learning and problem-solving and is generally positively experienced by farmers, but critics also see the risk of it being used by the state as a controlling mechanism (Bekele et al. 2016).

The ATA follows progress through its performance management agenda, but no official evaluation of the programmes has been completed. However, according to a few scientific studies, the success of the programmes has been mixed (Krishnan and Patnam 2013). This suggests there is room for other approaches to support farmers' technology transformation and productivity.

Systems approach in agriculture innovation

Central to innovation systems thinking is recognising that innovation happens through "*complex interactions between a multitude of players and sub-systems*" (Klerkx, Van Mierlo, and Leeuwis 2012, 464). It allows for a holistic understanding of the processes involved in knowledge production, adaptation and implementation and gives a more nuanced picture of the interconnected roles of the different stakeholders, recognising their challenges and needs (Hall and Clark 2010; Hellin and Camacho 2017; Hounkonnou et al. 2012). When managed well, an innovation systems approach will allow all stakeholders, including small-scale farmers, to interact, negotiate agreements, identify promising entry points, and influence the creation of new models and opportunities (Adjei-Nsiah et al. 2013; Röling 2010).

But in order to be successful, an innovation system also requires innovation capacity of its participants, that is, human capital, skills, capacities and competences, and in many cases also new working procedures (Lilja and Dixon 2008). There are many context-specific factors, both institutional and non-institutional, that influence innovation capacity. In many cases, there are also gender-specific differences and concerns. Focusing on building innovating capacity of women and mainstreaming gender into the innovation process, for example through guaranteeing representation of women, is central to sustainability.

A successful innovation process requires skilful facilitation or brokering, in order to balance power and solve barriers to networking between different stakeholder groups (Klerkx, Van Mierlo, and Leeuwis 2012; Madzudzo 2011). The relationships within groups, or more specifically between community members within existing networks, will also influence how support and information relating to agriculture and livelihoods is shared. Krishnan and Patnam (2013), who compare the effectiveness of official extension activity to learning from neighbours in adopting new technologies in Ethiopia, find that peer effects in social networks are central to choice. Initially, when introducing a new technology, the extension agents may be influential, but very soon the importance shifts to neighbours and other community members. This demonstrates the importance of unofficial social networks in society, as spheres where choice and change takes place.

Innovation platforms

Use of IPs is an approach for actively tapping into the innovation system. IPs have become increasingly common in the past years. There is no exact definition of an IP or model for how one should be set up and run. The definition formulated depends on the application of the IP. The basic principle is that an IP can be a tool to establish connections and networks between heterogeneous actors creating a space for exchanging knowledge regarding a common problem, that is developing and identifying local solutions to local problems (Cadilhon 2013). This is a core element of the agricultural innovation systems approach, in which innovation should be co-developed through a multi-stakeholder process promoting shared learning (Klerkx, Van Mierlo, and Leeuwis 2012). IPs have also been used as tools for more specific or limited tasks, for example, where the goal is to tackle a concrete challenge or to promote specific technology adoption (Hounkonnou et al. 2016). It can link the

local innovation system to work done by scientist, allowing farmers to participate in the whole research process.

Our IP was established with the aim of promoting the use of legume inoculation for sustainable intensification of smallholder agriculture. It was shaped as a joint discussion and training platform for farmers, extension agents, and experts, facilitated through monthly face-to-face meetings and annual workshops involving scientists and stakeholders.

But although IPs have become increasingly popular in both research and development projects, there are not many studies or frameworks for assessing their efficiency. A few good studies focusing on impact do exist and provide some suggestions on the central aspects of a working IP. Hounkonnou et al. (2012) review a development programme using IPs in 32 different locations to identify the potential of IPs to influence institutional issues. They find that in communities using IPs the innovative activity is more diverse. One of their key insights is the importance of identifying the right level and entry point for any given domain. For example, when the focus of the project was pest management in cotton, the entry point was creating capacity and opportunity of farmers to use new integrated pest management. When the domain was oil palm quality, the entry point was improving value chains for small-scale women processors (Hounkonnou et al. 2012).[1] However, they also conclude that the ability of an IP to generate change will depend greatly on the level at which it is working, whether at niche, regime or landscape, and whether the change is targeted at practical or institutional levels (Hounkonnou et al. 2016). The main reasons for failures, identified in the study, were linked either to members failing to institutionalise the IP in favour of projects with immediate short-term benefits or to failure of facilitation due to confusion or lack of clarity relating to decision-making and roles. National political issues, including pre- and post-election security concerns, were also identified as risks, again illustrating the importance of context for the success of an IP (Hounkonnou et al. 2016).

Similar issues are identified by Cadlihon and Davies et al. when assessing key factors for IP impact and success (Cadilhon 2013; Davies et al. 2016). Davies et al.'s building on Cadilhon's structure-conduct-performance framework, identify four interacting variables, significant for the effectiveness and performance of an IP, namely context, structure, conduct, and process. They define a theory of change for transforming impact at scale, including three interconnected change pathways; markets, intuitions and innovation capacity (Davies et al. 2016). Using this approach, they study a number of IPs and their performance. They find many positive examples where IPs have created stronger networks and higher levels of trust and information sharing between different stakeholder groups. In several cases, the capacity of local actors increased, including that of women. An example was an IP set up in Ghana to support mixed crop-livestock systems, through which women got involved in decision-making regarding livestock sales, previously considered a male activity (Davies et al. 2016).

A key insight of Davies et al. was, however, the highly context-specific nature of IPs. In addition to a conducive context, some level of innovation capacity is also required of participants in order to be able to participate actively in an IP. But participation also provides knowledge, new skills and opportunities, through which participants may acquire new roles as innovators and communicators in the community. Therefore, participation can build or reinforce innovation capacity. Compared to other extension methods, the IP approach has potential to better support co-innovation, learning and empowerment processes which can make it a better tool of the systems approach.

Analytical framework

Based on the theoretical background described above, we have developed an analytical framework (Figure 1) to structure the different aspects of an IP described in this article, and to respond to our three main research questions concerning: (1) the reception of IP as a tool; (2) its strengths and challenges; and (3) how to improve the methodology. Our framework builds on innovation systems thinking, suggesting that for new technology to be sustainably integrated into a farming system requires

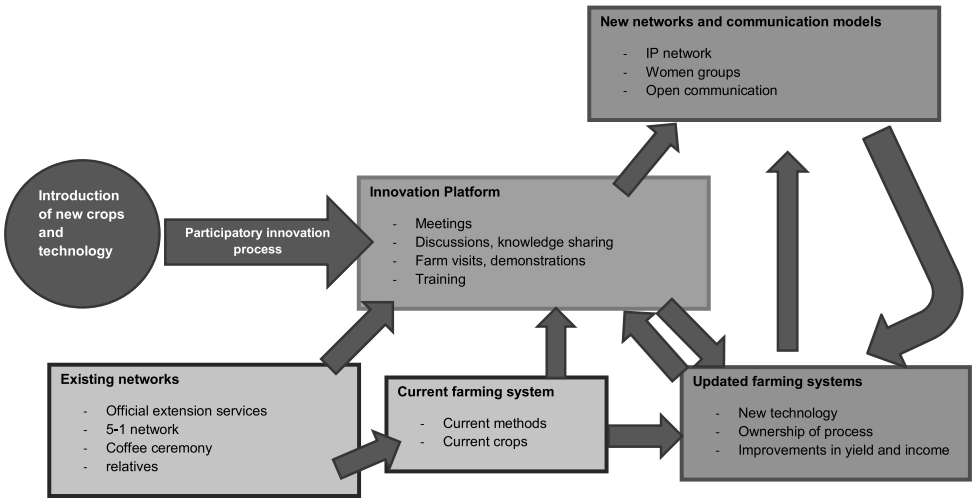

Figure 1. Analytical framework.

different community stakeholders engaging through a participatory approach. Both existing farming practices and networks in the community will influence the process. But through the IP's testing and feedback loops, new technology can be developed and integrated in a context-specific way. The IP activity itself is not hermetic but influences also other aspects of society in addition to farming, through the new networks, modes of communication and capacity of participants it creates. These new assets, in turn, may reflect back on the activity of the IP, through strengthened innovation capacity, making it a reflexive innovation process.

In Figure 1, the boxes on the lower left-hand side represent the current, context-specific situation, that is, existing farming systems, networks and information channels. The box in the middle is the IP activity itself, while the right-hand side boxes represent the outcome of the process and the new communication models and agricultural practices it has contributed to.

Case description and methodology

Ethiopia is a country of multiple different climatic zones and farming systems. Our study area is located in Sidama in the Southern Nations, Nationalities, and People's Region approximately 270 km south of Addis Ababa in the Rift Valley (Figure 2). The area is characterised by semi-highlands, with very small average farmland sizes. Among the households in our study, the average farm is 0.8 hectare, with 77% having 1 hectare or less (Table 1).

While farm size is small, household size is still quite large, causing additional constraints. In our survey, persons who had lived at least half of their time together with the household in the past year, where considered family members. In our data, the mean household size is 6.6 persons, ranging from 2 to 11. The mean number of children is 3.4.

Legumes are a central part of the local diet in Ethiopia. Many households have minimal access to meat and dairy products and legumes, therefore, represent the main source of protein. Legumes have the added advantage of being able to fix nitrogen from the air when inoculated with *Rhizobium* bacteria, improving plant growth and conserving soil fertility (Franche, Lindström, and Elmeric 2009). Using biological nitrogen fixation as biofertilisers provides farmers with an option to chemical fertilisers, which is a climate-friendly practice that is also economically beneficial.

Among our survey households, few grew only legumes on their plots. Intercropping with other crops was common. This suggests the use of *Rhizobium* may have an advantageous effect also on the intercropped plants. When reporting the main crop on their plots, only 14% had plots designated

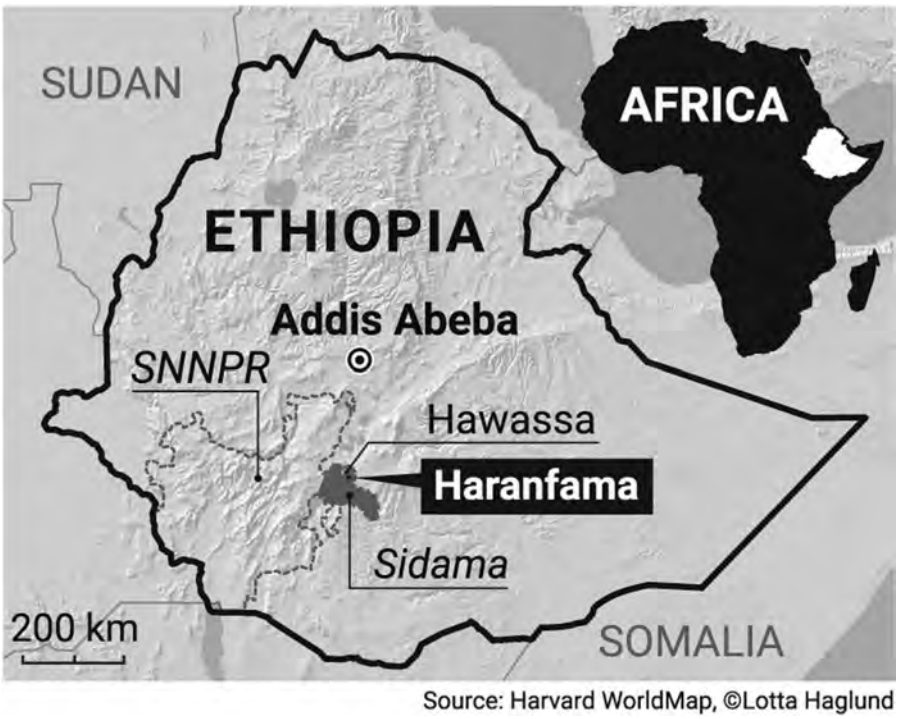

Figure 2. Site of the study area.

specifically to common bean, although a majority grew them. The most important food crop was enset, grown by 71% of households, followed by maize, grown by 47%.[2] The most important cash crops were chat and coffee, grown by 90% and 76% of households, respectively.

The project, implemented by a multidisciplinary team from Finland and Hawassa University, was based on a long-standing collaboration around rhizobia technology. Using inoculants with legumes as a biofertiliser was considered promising in improving both yields and soil quality. The IP process was one component of the multi-dimensional project, to facilitate the integration of legume and *Rhizobium* technology into the farming system, through an interactive process of sharing information, testing and development by local stakeholders.[3] The study focused on the process, trying to capture how the IP activity was experienced by the community, both members and non-members, as well as their contribution to the innovation process. We also wanted to identify the effect participation had on members' own experience in terms of farming practices, visions for the future, and role in the community, especially that of female members. Based on this information, the study attempts to identify the strengths and challenges of the IP approach in order to provide suggestions for future development of the methodology.

Data were collected throughout the project by different means (Table 2). The project started with a formative research phase to identify the most prominent farming systems and other context-specific

Table 1. Farm size of study households.

Farm size	Frequency	%
Less than 0.5 ha	21	35.00
0.5–1.0 ha	25	41.67
1.0–2.0 ha	8	13.33
2.0 ha or more	6	10.00
Total	60	100

Table 2. Data collected in the project.

Activity/data collection method	Source/participant	Type of information/data collected	Responds to research question
Formative research – household survey	Sixty households	Overview of current farming systems	Background information
Focus group discussions	Four groups of six to seven women	Women's opinions and experiences of current farming systems and their role in them	Background information
IP meetings approx. 1/month/report	Twelve farm households, six extension agents (second-year 18 households)	Meeting reports of the most important themes discussed, questions raised and solutions suggested	Question 2
Workshops/training sessions 1–2 times/year	IP members, experts from different fields, incl. Finnish project team	Workshop relating to specific theme or to discuss questions raised by the IP, e.g. soybean cooking and nutrition workshop	Question 2
Post-intervention survey	Sixty households	Households revisited to get feedback on the project from both IP members and non-members	Questions 1 and 2
Key informant interviews	Two female IP members, two male IP members and a community manager	Post-intervention interviews on the experiences and effects of the project/IP activity for members and larger community	Question 3

factors of the community, including gender roles. We completed a comprehensive household survey of 60 households in four villages, in two *Kebelles* (ward) in the Tula *Woreda* (district) close to Hawassa city. Data collected in the survey included an overview of farming systems, amounts of inputs and yields, information about family members as well as their age, educational level and main activity. This gave a good overview of the area, the farming systems and the main sources of livelihood.

Focus group discussions with a group of six to seven women were conducted in each of the villages to discuss activities and roles of women in agriculture and in the community as a whole. The focus was on women's roles in decision-making. We also discussed how opinions are changing, how the women see their future and what their hopes are for their daughters.

The IP was then set up and 12 households from the survey invited to participate. In the second year of the intervention, an additional eight households were included. A criterion for participation was that both spouses take part in all meetings. Local extension agents were also members of the IP, which was facilitated by an extension expert from Hawassa University. The IP met approximately once a month. The meetings included discussions about issues raised by IP members, including challenges relating to farming, but also suggestions for improvement. Demonstrations, farm visits and visits by experts were also organised for the group. IP meeting reports were compiled by the facilitator after each meeting, summarising participation, the issues discussed, the atmosphere of the meeting and any specific requests or suggestions. The themes and challenges brought up by members of the IP were fed back into the project, as a central aspect of the process was adapting the activities based on the needs and suggestions expressed by IP members. For example, the themes of the training were based on the participants' wishes.

A thematic workshop was organised each year. Themes included a nutritional training and soybean cooking workshop. Again, they were based on the requests and interests of participants. The participants were given biofertilisers developed from indigenous rhizobia strains for the particular crop (Aserse et al. 2012). In addition, they were given seed, both common bean, which is one of the staple crops in the area and soybean which was new to the farmers. All the activities organised and the support given to members of the IP, served as part of the approach. Evaluating the impact of this is part of question 2, that is, identifying the main strengths of the methodology.

At the end of the two-year implementation phase, the 60 households took part in a post-intervention survey, focusing on changes in farming practices as well as possible changes in household well-being more generally. One part of the survey specifically focused on the IP activity, how it

was experienced by the members, what changes it had brought and how the members now viewed their future.

As a measure of triangulation – combining multiple empirical materials or methods – we also conducted five key informant interviews post-intervention, to get a different perspective on the IPs. The interviews bring both depth and flavour to the survey responses. They allow for a better insight into people's experiences and minimises the risk of misunderstanding. Four of the informants were IP members, two men and two women. The fifth informant was a manager in the area, closely engaged with the project, but also very knowledgeable about other issues in the community, as well as previous initiatives and projects carried out. The interviews focused on how knowledge and innovation spread in the community, and the roles of different actors in this process, the key challenges farmers face in terms of adopting new technology and how the IP was experienced by and affected the community.

The survey data were collected through questionnaires by five master-level students from the University of Hawassa in the local language, sidamina. Results were entered into a database and statistically analysed using Stata 14 software. The survey questions, focusing on the most positive and negative aspects of the IP, were designed to capture how the IP was experienced by participants. Several questions also focused on the dynamics within the IP as well as in relation to the community outside. Through this line of questions, we tried to capture possible conflicts or challenges that may have existed or developed within the group, including hierarchy or power issues, and how these may have changed during the course of the activity.

The interviews were conducted by one of the Finnish social science team members, in collaboration with a representative from the University of Hawassa, who also had the role of interpreter, making the interview situation an interactive discussion. As the bulk of the analysis work was done at the Finnish end, it was the English version of this discussion that was transcribed. Key themes reoccurring in the individual interviews as well as in the survey were identified. Like Davies et al., we used Guests' content-driven approach to thematically analyse the information emerging from the data (Guest, MacQueen, and Namey 2012). This is an inductive method using an exploratory approach to the data, rather than predetermining themes or categories. The IP meeting reports, produced in English by the facilitator, were also reviewed to detect patterns and central issues raised by the participants.

Findings

Experiences by the local community of the IP approach (question 1)

The survey data were analysed to respond to research question 1. The farm household intervention did not measure actual biomass or yield, but rather focused on the farmers' subjective view regarding the effectiveness of the technology.[4] One of the questions asked in the post-intervention survey was whether yields had increased, stayed the same or decreased compared to two years prior. Forty-two percent of the respondents reported smaller yields, the main reason being drought. This is not surprising as 2016 was particularly dry in Ethiopia with devastating effects on large areas, although Sidama was not one of the worst-affected areas. However, a clear difference in responses could be seen between the respondents who had been part of the IP and those who had not. Eighty-eight percent of those who reported smaller yields had not been part of the IP, while 71% of those reporting higher yields had been participants. Out of all IP members, 60% reported higher yields. These responses likely reflect the result of the technology itself, but it also reveals a positive and optimistic attitude among IP participants.

Part of the technology offered to IP participants was growing soybean, which was new to the area. In the post-intervention survey, 34% of respondents reported changes in the crops they grew, most had started planting soybean. Interestingly, three households not part of the IP also reported growing soybean. This indicates that the information from the IP has spread in the community. This suggests

the IP may have an impact for the wider community, rather than being limited to participants. It will be discussed further relating to the strengths of the methodology.

The most important aspects of being part of the IP reported in the survey were the knowledge, experience and advice the participants gained, as well as the concrete technology – the biofertiliser – they were given. All respondents also mentioned their role in the community had changed. Most stressed the fact that they had become model farmers or otherwise had the opportunity to share the new experience with others in their community. The importance of this new status or role was found both in the responses of the men and the women.[5] All of the IP members said they were optimistic about the future and felt their capacity had greatly improved and they were now better equipped to deal with future challenges. Sixty-four percent stated that they expected their income to increase over the coming years, or that they would be more productive.

Most of the IP members were very actively engaged in the project and contributed ideas and suggestions. One suggestion was setting up control plots to concretely visualise the effect of the inoculant. This was done in the farmers training centre, but one of the extension agents removed the control plot due to poor growth. This was very disappointing to the IP members and reflects one of the challenges of facilitating a functioning IP. Many of the members, however, also set up their own control plots on their very limited farmland, which shows their positive engagement in the project.

Main strengths and challenges of the IP approach (question 2)

Based on our post-intervention data, it becomes clear that the participants of the IP have had an important role as active members, influencing the IP process. The meetings provided a new forum for discussion and participation, different from other forms of extension activity. Most of the IP members were very engaged in the project and helped spread the information within the wider community through existing networks and relationships. Some of the forums where information is traditionally shared in the community, both within religious groups, informal coffee ceremony and the more formal five to one network, in a sense became extensions of the IP. This could be seen, for example, through the fact that 45% of non-IP members taking part in the survey reported that they expected their income to increase over the coming year. The optimistic attitude and experiences of the IP spread in the community beyond the group of IP members.

However, the high expectations created through the IP activity can also be a risk of the methodology. For example, the case where the extension agent removed the control plot causing disappointment and negative feelings among IP members, reflects the risk of conflict if members have different levels of expectation and engagement. This highlights the importance of engaging all central stakeholders as peers in the process from the start, in order to guarantee ownership. It has to be a learning process for all involved where each will have to adapt to new and changing roles and modes of operation. This is perhaps the most challenging aspect of the approach, as there may be resistance towards change among some actors in the community.

This also highlights how essential skilful facilitation of the IP process is. In our case, the facilitator led the meetings in a way that empowered participants to express their opinions: "*Since the meeting of the platform is democratic, the leader of the platform gives equal chance to participants. So we have been actively participating*" (interview with Almaz, female farmer and IP member). When properly implemented good facilitation can prevent conflicts and provide a non-hierarchical environment, where both men and women feel comfortable to participate as active members and share their views and suggestions. Sharing of ideas is central for co-creation and also works as an avenue to empower all members. This is why we were interested in looking at the IP approach also as an avenue for more active women's participation.

Both through the initial focus group discussions and the interviews, it became clear that the role of women in the community is going through a change process. There is an awareness of the importance of equality and providing women with opportunities. In reality, however, both farming and

decision-making are still very male-dominated. Women generally do not have their own plots, but assist the men on their plots and perhaps farm in between the rows on these plots, mainly beans, cabbage, potato and pumpkin for home consumption. The growing of cash crops is mainly done by the men (FGD). However, many women did report having their own risk-mitigation measures. These included diversification, increasing their productivity, or starting small-scale entrepreneurship, such as processing maize powder, making biscuits or a small shop or coffee shop.

The key informant interviews confirm that the women participating in the IP process indeed benefited from it. Their skills and capacity as communicators improved and they were more likely to voice their opinion also in other situations in the community: "[Among women taking part in the IP] *there is a change of role, especially in communication and participation. The communicating skill is improving*" (interview with Hanna, member of IP and Kebelle leader group).

How can the IP approach be developed further as a tool of the innovation system (question 3)

According to all of the key informants, the IP meetings went through a major change process during the course of the programme. Initially, the meetings were facilitated according to an agenda set by the facilitator. Towards the end of the project, the role of the facilitator changed to observer, as the members took charge of the discussions, which ranged far beyond agriculture to issues relating to business, education and health.

> "The capacity of the members increased significantly. In the beginning we are waiting for agendas, but now we cannot wait any agenda from the leader – any member of the IP can initiate agenda and now we are active participants … Initially we started to discuss related the technology provided to us by the programme, but now we are not limited to the technology, but we're discussing about every aspect that can improve our livelihood, about other technology, land preparation, about marketing, weed control and the like." (interview with Shifara, male farmer and IP member)

As the IP activity proceeded, we found that new concerns raised through the activity triggered new or different needs for support (Kilelu, Klerkx, and Leeuwis 2014). Although the project attempted to use the IP as a tool to engage different community stakeholders, focus was on the farmers, the most important target group for the technology. However, we found that the participation of extension agents was central. Although the farmers were the most active members of the IP, suggesting new ideas and solutions, the extension agents are central for the sustainability of the project. The case where the demonstration plot caused conflict suggests taking on new roles may be challenging for some participants. Therefore, this needs to be an integral part of the IP design from the start. Facilitating this process carefully is perhaps the most important aspect of developing the methodology further. Training extension agents as facilitators, not acting from a higher position in the hierarchy, needs to be at the centre of the approach, in order to develop the local extension system into a more inclusive direction.

One approach is to recognise the role of extension agents as experts. For example, a technology such as using *Rhizobium* inoculants as biofertilisers requires training of farmers, and therefore skilled trainers. Taking on the role as a trainer can provide new opportunities for extension agents, which can be motivating and rewarding.

Discussion and conclusions

Our study aimed to analyse the IP as a tool for community co-creation from a participatory innovation systems approach. We focused on how the IP methodology was received by the local community, what the main strengths and weaknesses of the approach were, and based on these results, in the context of the specific case study, identifying lessons learnt and suggestions for developing the method further.

We found that if well managed, the IP process builds capacity of all participants to co-create methods that respond to context-specific needs. This requires functioning feedback loops and commitments. Extension agents will be able to improve their own work to support farmers, if they internalise the benefits of empowering farmers to actively participate in the innovation system. This is part of understanding the reflexive nature of the IP process; how the IP activity can trigger the creation of new networks or use existing ones in new ways within the community. This is likely one of the major strengths of IPs compared to traditional extension models including short-term training or demonstrations for groups of farmers. In comparison to the commercial village project studied by Kilelu, Klerkx, and Leeuwis (2014), which found quite a few challenges in terms of gaps and conflicts between groups, the IP may have the additional benefit of being smaller and easier to manage. This can strengthen the experience of ownership of the process both for extension agents and for farmers and lead to new development tracks.

> "When I compare this IP to other projects, it capacitated or empowered the community more. It gave a chance to the community members to explore their internal potential. Also it allowed or gave chance to discuss their problems and on potential solutions … So I think this project is comprehensive project that capacitate and empower community to solve the problems by themselves." (interview with Temesgen, community manager)

New knowledge, roles and division of labour within the community will mean changes in communication- and power dynamics. This requires a socially sustainable process, in order for it not to cause conflicts or other challenges. The IP can in itself be part of the reorganisation of community dynamics, if the feedback loops are well managed, making it an iterative learning process. Based on these insights and experiences of the project, we have updated the theoretical framework to include the feedback loops as key aspects of a functional, reflexive IP process (Figure 3).

An important aspect to consider in developing the methodology further is how these processes could be linked even more strongly to policy through targeted interventions. Future potential developments of local IPs, to scale up their activity, could be establishing local thematic cooperatives linked to the IPs. In our case in Ethiopia, establishing a soybean cooperative could be a possibility. After testing soybean with biofertiliser in the project, most IP members were interested in continuing to grow it. Their challenge was, however, the limited size of land, out of which a significant part is allocated to their current cash crop, chat.

Due to the project, some of the households were able to save and store part of their produce for a longer period. Growing soybean can also increase women's income, as it has a higher market price than common bean – especially if they can sell it to a larger market, for example through a

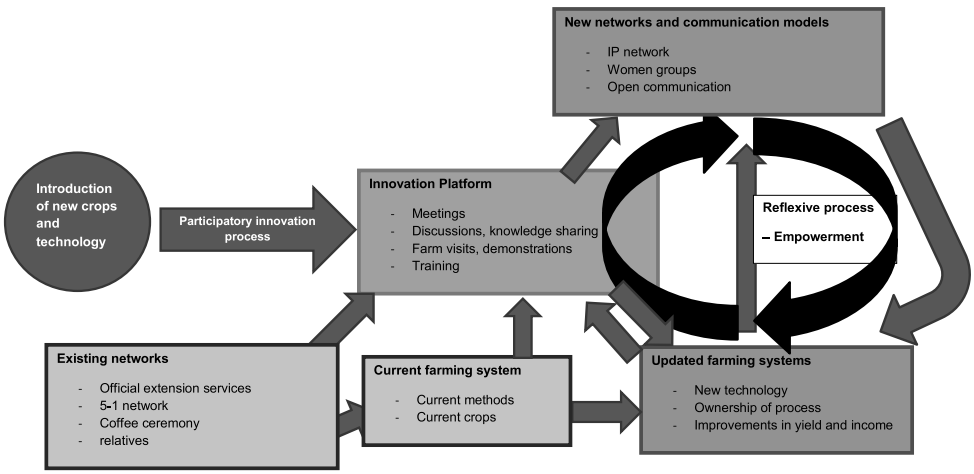

Figure 3. Updated theoretical model.

cooperative. If a local soybean cooperative was established, with enough output to justify accessing larger markets, this could potentially prompt farmers to transform from chat to soybean, which would likely have beneficial effects both for local nutrition and for soil quality. The IP held initial discussions about a cooperative and links were built to the local cooperative umbrella organisation. Also, new livelihood opportunities based on the processing of soybean products could be options to explore. This will require further development of feasible practical solutions. The best place to have these discussions will of course be in the IP.

Notes

1. In this context, Hounkonnou et al. (2016) define a domain as "*a potential system of interest and action among professional and political actors who have a stake in the domain*", rather than defining the domain as referring to a homogenous group of, for example, farmers with similar challenges and requirements.
2. Enset is also referred to as false banana, as it resembles a banana plant without fruits. The root is used for food consumption through a complicated process including fermenting parts of it underground for several weeks. It is then dried and ground into kocho, which is one of the staple foods in the region.
3. The SOILMAN project also included a field trial testing the biological effect of the technology in collaboration with the national research centre, as well as supporting several Ethiopian doctoral students.
4. The field trial set up with Hawassa research institute showed the project's rhizobial strains were very effective in comparison both to locally produced inoculants and to chemical fertilisers (results forthcoming).
5. Of the respondents of the endline survey who had been part of the IP, 14 were men and six women. All reported gaining a new role in the community through sharing experiences with others, becoming model farmers, or achieving new acceptance by the community.

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This work approaches some of the most pressing global challenges of the coming decades from a small-scale farmer's perspective. These challenges include climate change, biodiversity loss, growing populations and food insecurity. In Africa 70% of the population is still involved in agriculture for their income. Small-scale farmers, especially women farmers, represent the poorest and most vulnerable group that will be most affected.

Improving livelihoods and wellbeing of small-scale farmers will require a number of different context-specific solutions. Indentifying the most relevant ones requires an Innovation Systems Approach where local needs and voices are heard, and solutions co-created. The case studies in this work provide some examples, ideas and lessons learned that may contribute to developing such pathways towards sustainability.

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