Analysing the socio-technical transition to conservation agriculture in Uganda through the lens of the multi-level perspective

Sara Helen Kaweesa¹ · Hamid El Bilali² · Willibald Loiskandl³

Received: 25 July 2019 / Accepted: 6 August 2020 / Published online: 15 September 2020
© The Author(s) 2020

Abstract

Conservation agriculture (CA) is based on three principles, namely minimum tillage, crop rotations and maintaining a soil cover. The research used the multi-Level perspective on socio-technical transitions to analyse the dynamics of CA in Uganda. The analysis of the CA niche is structured along the socio-technical regimes and explores the impact of the transition. Data were gathered from Alebtong, Dokolo and Lira districts in mid-Northern Uganda. The results indicate a steady transition towards CA that can be supported to eventually scale up. The legitimisation process of CA transition involved wider implementation by farmers on their fields, validation through adoption by the wider communities and at the national level. The process seeks policy and institutional promotion, more scientific publications of local research findings, validation by legal standards and judicial reasoning, raising civic awareness, stakeholder dialogue and mobilisation of political will to advance the purposes of CA in contrast to conventional agriculture. CA caused changes in practices, perceptions and motivation among the niche actors with respect to agricultural sustainability. However, scaling up could further be enhanced when market policies, credit and financial environment are reconciled.

Keywords Socio-technical · Transformation · Culture · Niche · Regime

1 Introduction

Agricultural production needs to grow to meet the demand of population growth amidst farm labour shortages, changes related to climate change, rural to urban migration of young people and changes in consumer preferences. It is necessary to shift

✉ Sara Helen Kaweesa
shkaweesa@gmail.com

¹ Institute for Development Research, University of Natural Resources and Life Sciences, (BOKU), Vienna, Austria

² International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM-Bari), Valenzano (Bari), Italy

³ Institute of Hydraulics and Rural Water Management, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

farming practices from conventional practices to those that sustainably allow for higher yields and increased productivity, especially in agrarian-based economies. Increasing resilience to extreme weather patterns in rain-fed agricultural areas is also of vital importance.

Technologies generally help farmers to make necessary improvements in agriculture. There are several technologies that have readily been taken up elsewhere unlike in sub-Saharan Africa where the rate of adoption of technologies is slow and low. Conditions remain to be understood. Conservation agriculture is considered as one of the novelties (cf. niches) and has been analysed in studies on sustainability transitions in agriculture (Vankeerberghen and Stassart 2016). Therefore, the present study looks at the social conditions around the uptake of conservation agriculture (CA) in Northern Uganda. There are other reasons behind the general hindering factors that include low technology adoption e.g. low fertilizer use; ineffective and limited extension services giving haphazard interventions (Kuteesa et al. 2018); seed gap (Mbowa and Mwesigye 2016); counterfeit inputs (Bold et al. 2015; Mbowa et al. 2015) and the weak institution coordination that all told hinders technology diffusion. Based on recommendations from previous studies such as (Andersson and D'Souza 2014; Mutyaba et al. 2016) research on CA adoption could benefit when done using available scientific frameworks and or some theories of change. Some authors (Pan et al. 2018; Hall and Clark 2010) understand innovations as changes that take place in societies, when knowledge, technology, and information are made available and put into socially and economically productive use. For technological innovations to succeed, they must build on relevant social structures and be able to influence these structures. Radical development demands simultaneous technological and social change while integrating human, social, and natural factors to help unlock peoples' ability to respond to natural resource management challenges among others (Scoones et al. 2007). Social systems too have a role to play in resource management i.e. attitudes, mind-sets, and appropriate technologies are also critical to the entire process. Therefore the contextual factors, social and institutional environments, power dynamics and vested interests surrounding CA adoption needs to be explored (Corbeels et al. 2014) in a specific context. This is necessary because available studies indicate that adoption is site specific (Thierfelder et al. 2016; Baudron et al. 2015) and that it also depends on the resource allocation strategies of the farmers.

CA is a low-input technology based on three principles, namely minimum soil disturbance, maintaining a soil cover through mulching with crop residues or planting cover crops and practicing crop rotations. The technique has several benefits such as conserving soil and water (Mubiru et al. 2017), reducing labour in the long term, increasing yields and reducing the effects of climate change variability (e.g. floods and droughts) (Hobbs et al. 2008). CA also addresses soil degradation over the long term, increases food production while ensuring protection of natural resources and enhancing the conservation of biodiversity, two advantages that are critical in the developing world (FAO 2015; Corbeels et al. 2015). Based on this evidence and approved benefits, it would relatively be easy to make a transition from conventional agriculture to CA, yet this is not the case as is seen on other continents like South and North America where it has been practiced for close to four decades (Friedrich et al. 2012; Giller et al. 2009).

In Uganda, CA is already yielding benefits in fragile ecosystems, which are highly degraded and vulnerable to climate change, such as in Nakasongola District (Mubiru et al. 2017). Other benefits from CA are reported in Eastern Uganda (Vaiknoras et al. 2014) and in mid-Northern Uganda (Kaweesa et al. 2018). The study of (Nyende et al. 2007) is perhaps one of the early works showing the status of CA in Eastern Uganda.

It would therefore be necessary to enhance the uptake of CA in the country given that these benefits are already evident but on a few farms and on a small scale. Also, CA seems a good fit to the small land holdings as all those that had adopted it were small-holders. There are several small pockets of CA being implemented in several parts of the country. The pattern of these findings is no different from several other African countries (Kassam et al. 2017) where CA is awaiting scaling up. This can be enhanced, for instance, because actors that are willing to provide the hands-on experience increase likelihood of scaling up. This strategic action of pioneers is like the emergence of niches in organic agriculture (Hauser and Lindtner 2017) in Northern Uganda. However, these need to be brought to speed in order to address the looming food security and environmental challenges. Almost 70% of Uganda's land was degraded by soil erosion and soil nutrient depletion between 1945 and 1990, especially in hilly and mountainous areas and highly populated areas. Moreover, more than 20% of agricultural land and pastures in the country were irreversibly degraded (Dregne 1990). Studies also show soil nutrient depletion, mostly nitrogen among others, mining and little or no replenishment of nutrients (Nkonya et al. 2005). Ranking 104th in Global Hunger Index 2019, food insecurity in some regions of Uganda is between serious and alarming (Von Grebmer et al. 2019). Indeed, regional inequalities in food and nutrition security critically persist as well as pockets of chronic food insecurity and undernourishment among children under 5 years, refugees and vulnerable groups. Maize, beans and bananas remain important for food security (UBOS 2018).

2 Methodology

2.1 Theoretical framework: Multi-level perspective on socio-technical transitions (MLP)

The study employs the multi-level perspective (MLP) to analyse CA as a niche and to understand the dynamics and processes leading to the transition to CA. MLP is one of the current heuristic theoretical frameworks that helps to explain how societies change and develop (Geels 2002; Geels and Schot 2007; Geels 2010, 2011). The MLP framework was originally applied to the energy and transport industries but has recently been used to study other sectors such as agriculture (Sutherland et al. 2014; Darnhofer et al. 2012; El Bilali 2018). It has proven to be useful in understanding pathways in sustainability transitions.

The MLP is made of three components: niches (where new ideas develop), the regime (mainstream activities and structures) and the landscape (society trends and global changes). A niche is a small specialised space that allows new ideas or innovations to develop, grow and freely function while being protected from the mainstream system (Smith et al. 2010; Geels 2011). The socio-technical regime is a way of doing things (i.e. how things are organised or arranged to operate in each setting) and the mainstream activities and structures. It is the network of social groups and actors, the rules (formal and informal) they maintain to run a dominant socio-technical system and related material/technical artefacts (Geels 2011). The regime tends to change only incrementally (Lachman 2013) under the influence of the landscape. The landscape is the external level that influences and sets world trends. It refers to factors that put pressure on the regime and create opportunities for the niches. The landscape includes trends and events such as macro-economic trends, demographic trends, political and ideological developments, deep changes

in societal values and climate change (Lachman 2013; Smith et al. 2010). In the MLP, transition is defined as the shift from one regime to another and it results from the interaction processes at niche–regime–landscape levels (Geels 2006, 2018c, b, 2011; Grin et al. 2010; Markard and Truffer 2008). However, a more nuanced conceptualisation of transition was recently presented by (Geels 2018a) that suggests to move from “*bottom-up disruption (driven by singular niche-innovations) to gradual system reconfiguration, which represents a more distributed, multi-source view of change*” (p. 86). In this respect, different processes and mechanisms have been suggested to describe the interactions between niches and the socio-technical regime. Elzen et al. (2012) use the term “anchoring” to refer to niche–regime interaction that leads to durable, long-term niche–regime linkages. Indeed, niches can anchor to regimes by proposing new institutions or rules, fostering new technical systems (e.g. technologies, practices and processes) or building new social networks and groups. The MLP stresses the importance of the alignment of processes at niche, regime and landscape levels for a transition to happen (Geels 2011, 2012, 2018a). Depending on the nature (symbiotic/competitive) and the timing of the multi-level interactions between the MLP elements (i.e. niche, regime and landscape), Schot and Geels (2007) distinguish between different transition pathways, namely reproduction (cf. stable regime and no transition), transformation, de-alignment and realignment, technological substitution and reconfiguration.

MLP was recently used to study sustainability transitions in agriculture and food systems (El Bilali 2018, 2019b; El Bilali et al. 2017). In this context, El Bilali (2019b) shows that MLP was used to analyse the emergence and/or development of different niches such as agro-ecology, organic agriculture, permaculture, urban agriculture, conservation agriculture, integrated farming, care farming and alternative food networks. Analysing the CA niche in Uganda followed guidance in the study of Isgren and Ness (2017) and Geels (2012, 2018a) on the dimensions of the socio-technical regime (hereafter named “regime dimensions”), namely guiding principles, practices/technologies, knowledge, market relations, policy and culture. Indeed, the validity of the used approach stems from the fact that Isgren and Ness (2017) used the same regime dimensions in their analysis of agro-ecological transition in Western Uganda; a context that is very similar to that of the present study. As pointed out by Isgren and Ness (2017), “*Applying regime dimensions to a niche-level phenomenon might seem contradictory; however, the point was to anticipate regime level implications of scaling up the niche*” (p. 7). Also, (Smith 2007) refers to “socio-technical dimensions” and underline their usefulness in making explicit not only the composition of regimes but also how they contrast alternative niches.

CA sustainability transition in this article uses the MLP as an orienting framework to analyse the alignment of processes within and between the three levels, viz. niche innovations, socio-technical regimes and exogenous socio-technical landscape. We discuss the phases, actors involved and challenges to understand the complexity of CA transition and to provide policy advice and provide analytical traction, i.e. moving away from focusing on farmers and the green economy and instead offering wider integrative views in broader societal context.

2.2 Data collection

The research was carried out in three districts in mid-Northern Uganda. The sub-region is one of Uganda’s poverty and environmental degradation hotspots. Having suffered war for two decades added complexity and left the region characterised by regression. The area is

additionally notable for land use conflicts. It has one of the highest incidence of poverty at 43.7% compared to the national average of 19.7% and moreover, 43% of the population is at risk of rebounding into poverty. The same trend is true of high inequality represented by a Gini coefficient that rose from 0.331 in 2005/2006 to 0.378 in 2012/2013 (UBOS 2017).

Data were collected in the period January to July 2017. The qualitative methods used included focus discussion groups (FDGs), key informant (KI) interviews and a workshop to discuss and validate preliminary findings while still in the field.

For the KI interviews, expert sampling was used to select respondents as a way of eliciting expertise of CA and their knowledge, insight and experience of farming in the region. The KI were selected from Lira District because it hosts the main administrative structure of the region. The respondents were composed of relevant persons from different institutions. There were ten interviews conducted by the researcher and administered to the following personnel.

1. The main Agro-input supplier in Lira. She was also a medium-scale CA farmer.
2. The Agricultural Extension worker at sub-county level.
3. The Lira District secretary for production and marketing.
4. A male local government representative from the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) of the Government of Uganda.
5. The woman district agricultural representative from MAAIF.
6. A supervisor of Operation Wealth Creation (OWC) in Lira. OWC is a representative of the former National Agriculture Advisory Services (NAADS) and a statutory semi-autonomous body under the MAAIF. This body has a mandate to manage the distribution of agricultural inputs to farmers.
7. A leader of a Non-Governmental Organisation (NGO) implementing CA in the region.
8. The Agriculture Officer in charge of promoting CA from Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI). NgeZARDI is an agency for technology development and agricultural information dissemination under the National Agricultural Research Organisation (NARO). NARO is a public institution responsible for guidance and coordination of all agricultural research activities in Uganda.
9. A policy analyst from the Ministry of Finance.
10. A pioneering CA implementing Officer who worked for the Food and Agricultural Organization of the United Nations (FAO) in 2000.

The researcher randomly selected participants from each of the three districts to participate in six FDGs. The FDGs were gender biased given the social and cultural setting of the area where the study was done. Below is a summary (Table 1).

Both the KI interviews and FDGs were guided by a checklist of open-ended questions drawn from the MLP levels with a reference to the regime dimensions. These included policies, institutional factors, social cultural factors, markets and generally questions on knowledge and practices and constraints of CA adoption specific to the region. In some of the FDGs where the participants could hardly speak English, a local field research assistant, who could speak both English and Langi (local language/dialect), facilitated the discussions.

Interview and FDG data were transcribed and analysed. Some of the audios that were in Langi or some other local dialects were transcribed by a field assistant that could directly translate the information into English. The content on the transcripts was checked, grouped under the different themes from where it was analysed for main points

Table 1 Number and gender of participants to focus discussion groups (FDGs) and workshop

District	Sub-county	Village	No. of men	No. of women	No. of FDGs
Alebtong	Awei, Acede Parish	OkwaloAgabo B	7	6	2
Dokolo	Bata, Alapata Parish	Anyangocoto	9	6	2
Dokolo		Alanyi B	Mixed		1
Abia cooperative	Control group		6	6	2
Lira	Agali, Adyaka Parish	Anyapo	6	6	2
Total			28	24	9
Workshop in Lira			14		

that the respondents discussed. This information was combined and forms the results and discussion section below.

Data were also analysed for possibilities of CA to attain “thick legitimacy” based on the study of Montenegro (de Wit and Iles 2016). Indeed, Montenegro (de Wit and Iles 2016) put it that “*both agro-ecological and scientific legitimacy grows out of a web of legitimisation processes in the scientific, policy, political, legal, practice, and civic arenas*”. Therefore, the paper analyses the legitimisation process used by the actors supporting CA in Uganda by focusing on the following processes: carrying out research on the knowledge and practices of CA; extending its influence in the power arena particularly under policy, practical and civil arenas; and, third, stressing the ethical legitimacy of CA.

3 Results and discussion

The MLP explains change in society at three levels starting, first, with the innovation itself also called the niche. Second, the socio-technical regime which is influenced by policy, culture, science, market, industry and technology. If the niche innovation is to be successful, it has to break through this dominant level. And third, the socio-technical landscape is simply external global factors that pressure the dominant regime. Our results are presented in that order using synthesised information from both the KI and the FDGs.

3.1 CA Niche

CA is a niche because it breaks away from conventional agriculture that involves the tradition of burning of crop residues and deep ploughing. This CA knowledge generally exists but only in numerous small pockets scattered around the country, i.e. from the NGO dissemination and training workshops, government and donor funded projects in selected areas of operation. It was clear regardless of circumstances that farmers were ahead on CA information unlike some of their political leaders. For example, some of the key informants, who were political representatives, showed less knowledge of CA although their opinions on transitions greatly differed. The more highly political informants were of the view that for a meaningful transition to be made at a country level, agriculture would have to become commercialised. For some, this includes introducing activities and programs that would eventually cause smallholder farmers to move away from farming their small pieces of land in search of off-farm work like factory work.

Although FDGs were organised according to gender, both male and female FDG participants expressed positive opinions of CA just like they did in the workshop. However, they equally referred to inadequate access to training and extension services as one workshop participant stated below:

I would even say that the extension workers are having the training gap e.g. on the changing climatic patterns. They need relevant knowledge and skills in responding to these challenges because it is very vital. I am doing a masters in sustainable agriculture and rural development but when I see the problems farmers face, I remember that the gap is still very big

However, due to post-war events and other factors, like high inequality and poverty in the area, participants expressed little trust in relevant government agencies. Participants cited the fact that there was hardly any agricultural extension except upon farmers' demand.

3.2 CA knowledge

At higher and tertiary institutions of learning, such as universities and agricultural colleges, there is hardly a CA curriculum. There is even hardly a module on CA. However, there are demonstration plots in some primary schools and in lead farmers' fields in the communities. In the past, there was some CA research undertaken at the Ngetta Zardi and at other NGOs that promoted CA. These had some project reports for the areas where their projects were implemented, but largely remain unpublished. Given this reality, there is an inadequate access to the necessary information. Except for information sequenced around world environment-related events and days, there is hardly any information dissemination over the media or even from the government extension services. The only information readily available to the farmers is that given by NGOs that run projects on CA. Other than that, there is peer education (cf. farmer-to-farmer extension) where farmers pass on the information to those in their circles such as friends and neighbours and or demonstration plots situated on roadsides to catch the attention and generate interest of passers-by.

It was evident that farmers were well versed with CA knowledge and could clearly point out to some of the technology benefits and achievements so far attributed to revenues from the venture. Some of the women in the FDGs recounted their sources of information, peer support and showed off their achievements and are quoted below.

Female Respondent 1: "We have been hearing on our community radio and the REDs cap project came in; they stayed with us, taught us, trained us and told us what CA is about. This plot of land with my shop there, I bought it from CA. The very first crop that I grew was maize, I mulched and then sprayed on one acre, the maize was up there and the yield you cannot imagine. I got 600,000 UgX from the maize. So that is the foundation."

Female Respondent 2: "My story was just like that of Anna; do you see that building foundation over there? While she was growing maize, I grew soya. We were doing it together."

Female Respondent 3: "For me I planted maize and it yielded very well which enabled me get some money to pay for school fees for the children. The technology is quite cheap and with proceeds I have been able to build a house".

Female Respondent 4: "saw Anna and as she was trained by her, she grew maize which gave her bigger yields. After a few seasons, she bought a cow out of that

money. When the cows were many she sold and then constructed for her mother a house”.

On the whole, several other projects followed in many parts of the country albeit under different circumstances, for instance, from school demonstrations, observations between neighbouring farmers and learning between group members, friends and neighbours, seeing their results and asking them to share their knowledge. Farmer group members shared their knowledge coupled with the results of their demonstration plots. When the farmers tried the technology, they got the results. There were also records kept so that farmers would see the changes themselves and in a way be motivated by the observed higher yields.

However, given the weak extension system, the above efforts are still way below expectation. At the time of study, there was hardly any extension services being offered to the farmers in the area of study. The results showed that 90% of the farmers had never had an extension worker telling them about climate change or even CA. An interview with the KI who was an extension worker confirmed farmers’ opinions regarding the few extension workers. Although figures vary across Uganda, the ratio of extension worker to farmers is approximately 1:2500 to 1:1800 compared to the recommended global figure of 1:500.

3.3 CA technologies and practices

CA practice is relevant to the farmers in most of the agro-ecological zones in Uganda. Studies so far indicate increases in yields and associated increased incomes, profits and reduced soil erosion on degraded soils (Mubiru et al. 2017; Vaiknoras et al. 2014). Discussions with participants (cf. FDGs and KI) in the study area show that farmers find CA applicable, except for one principle of mulching that is rather demanding and nearly not practical. Mulching in most cases remains a challenge due to the competition with fodder for livestock. In this case, some farmers resort to planting cover crops that provide a soil cover and at the same time fodder for animals. Smallholder farmers, who are the majority in the study area, practice the CA principles albeit at different degrees. They use hand hoes and/or ox ploughs to dig permanent planting stations and rotate their crops, broadly speaking, between legumes and cereals.

At an advanced level up from hoes, manual rippers and ox ploughs would be the appropriate step. Better still, affordable motorised rippers suitable for the predominate small farms would enable farmers to catch up with the rains in the planting season. These and other current technologies would attract the younger generation of the currently jobless farmers and at the same time ease the workload of the ageing population of rural farmers. In Lango, the mere fact that farmers were able to repair their rippers when they broke down is a sign alone that they are committed to adopting technologies.

Observations in the field showed some problems like few shared ploughs for those who could afford to hire them while the vast majority resorted to manual revolving community groups. But, at the same time, many farmers were frustrated as they could hardly access the scarce hire services and so these fell back to conventional agriculture even if they knew the benefits.

Most farmers chose the technique after being taught either by NGOs or their peers, and this shows that knowledge played the greatest key in the switch to the technology. This peer-to-peer exchange provides informal learning for other farmers who are interested to receive knowledge. Most farmers also practiced at least two principles of CA for labour reasons, viz. minimum tillage and crop rotation; these were readily done because of the social or community labour dynamics, i.e. through the revolving self-help groups made up

of trusted friends. The farmers are organised in their respective groups and with administrative structures all in place and receive available information and services through this arrangement. However, it might be worthwhile to create space to allow these and more informal small technological growth process.

3.4 Markets

Market availability of CA products does not differ from that of conventional agriculture products. However, perhaps as consensus is built with numbers of CA rising through increasing adoption and expanding the acreage of CA, volumes of products from CA could be an advantage in the market. FDG participants decried a challenge of market that is dominated by middlemen. One male respondent commented as below:

I studied in Soroti in Arapai Agricultural college, but after finishing my studies I failed to find a job. However, with my knowledge of agriculture I started growing soya beans. The challenge was that the market was not good. In the meantime, I recalled from school, the teachers told us that one of the benefits of being in a cooperative was the bargaining power. I therefore decided to join a farmers' group so that in case the buyers come to us we would be together set a better price other than them exploiting us.

Another respondent added:

While in Aterayong, I was with my members and we were very strong, but after this cooperative was disbanded, I went back home started producing my crops but the pricing wasn't okay so I saw that it wasn't good to stay like this, so I decided to go back and call my people to join the cooperative, because of the benefits that I knew I would get was more than when am alone, so that was the reason why I called them back to the cooperative.

Farmers in the FDGs clearly explained how they end up selling their CA products to middlemen at rock-bottom prices due to the widespread poverty. On the other hand, markets are also affected by other factors. For example, there was hardly a functional bulking system in the communities let alone appropriate post-harvest handling facilities or even any reasonable silos or food reserve storage system. And then, again rural households are unique in terms of needs, expenditure and how they respond and or meet their responsibilities. For instance, without affordable health insurance and a general lack of decent public facilities (e.g. education and rural infrastructure), farmers' productivity and incomes are badly compromised.

3.5 Policy

The agriculture sector employs the greatest percentage of Ugandans (UBOS 2018) and so investing in the same is the key to achieve poverty reduction and food security in Uganda. Since the year 2000, agricultural investment has been guided by the Plan for the modernisation of agriculture (PMA). But even so, the expenditure was below the recommended 10% of annual government expenditure to the agriculture sector based on the Maputo Declaration, 2003. For example, in 2014/2015, it was 5% of the total domestic budget. In the 2020/2021 budget framework, the sector will receive \$255 M that is expected to come from

external sources like donors. Most of this amount is expected to be spent on large investments that would be considered of little value to smallholder farmers, for example support to cooperative unions, which faded out as one FGD participant who was a renowned leader in the past government regimes asserts below:

I was under Aterayong cooperative and also chairman of the Lango cooperative union if you can remember. The government came up with their policy to try to deny cooperatives support, so they left them to stand on their own. As a result, Lango cooperative struggled on its own, especially with the then huge debts from the other banks. Eventually these banks came and took everything from the cooperative so this led to its collapse, so up to now its non-existent, that is what I can talk about Lango cooperative

3.6 Landscape

Doing CA would have a positive impact and reduce landscape pressures such as climate change variabilities and other factors like land and soil degradation that require sustainable methods of farming. At the global level, there are international agreements and treaties that Uganda as a signatory would have to comply with.

Uganda is signatory to international treaties that are relevant to agriculture such as the constitution of FAO, which leads efforts on fighting hunger; the Right of Association (Agriculture); the United Nations Framework Convention on Climate Change (UNFCCC) that deals with climate change action; the International Seed Treaty that guarantees food security through biodiversity conservation; Agreement establishing the African Development Bank; Constitution of the United Nations Industrial Development Organization (UNIDO); and the East African Community (EAC) Treaty that established cooperative commercial and political relations for their citizens among other agreements. Uganda also made commitments to the Sustainable Development Goals (SDGs) and to implement the Rio Declaration, Agenda 21 and its outcomes. Others include the New Partnership for Africa's Development (NEPAD), Environment Action Plan and the Comprehensive African Agriculture Development Programme (CAADP). The country has also taken steps towards achieving sustainable land management (SLM). Altogether, these efforts are geared towards increasing investments and ensuring sustainable growth, productivity, economic development and scaling up SLM practices, improving research and knowledge and coordination of the stakeholders. Climate-Smart Agriculture (CSA) is promoted by MAAIF with support from the Common Market for Eastern and Southern Africa (COMESA), FAO through UNDP and other donors including the European Union (EU), the Department for International Development (DFID, UK) and the Government of Norway. CSA is an approach that guides strategic actions needed to sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change and also reduce greenhouse gas (GHG) emissions. It contributes to the achievement of the Sustainable Development Goals (SDGs) 2 (Zero hunger), 13 (Climate action) and 15 (Life on Land), among others. In Uganda, the CSA program is aimed at developing technical, policy and investment conditions to achieve food security, strengthen livelihoods and management of natural resources and adoption of agricultural technologies.

In the CSA policy environment as outlined in Table 2, government institutions are responsible for the implementation of the policies and actions following government decisions (FAO, 2010, Ministry of agriculture animal industry and fisheries (MAAIF) and Ministry of water and environment (MWE), 2015, CIAT and BFS/USAID 2017).

Table 2 Key policies relevant for CSA implementation and scale out in Uganda*Regional: Africa*

Comprehensive Africa Agriculture Development Programme (CAADP)

Based on four reinforcing pillars for investment in agriculture to improve performance through strengthening country presence, focused lending program based on coordinated sector plans, enhanced capacity for policy, analytical work and knowledge/partnership management (NEPAD 2003).

Uganda: Agricultural Sector

Plan for Modernisation of Agriculture (PMA)

Since 2000, investments in agriculture were guided by the Plan for Modernization of Agriculture (PMA) whose main objective was to reduce poverty through agricultural commercialisation (Uganda. Ministry of Agriculture and Uganda. Ministry of Finance, 2000).

Agricultural Sector Development Strategy and Investment Plan (DSIP)

The PMA has since 2010 been replaced by the DSIP. The DSIP is based on a vision of the future, which is to have “a Competitive, Profitable and Sustainable Agricultural Sector”. Investments under DSIP have been packaged under four Programmes representing the key areas of opportunity: (i) Enhancing Production and Productivity; (ii) Improving Access to Markets and Value Addition; (iii) Creating an Enabling Environment; and (iv) Institutional Strengthening in the Sector (MAAIF 2016).

The National Agricultural Policy 2013

The vision of the National Agriculture Policy is “a Competitive, Profitable and Sustainable Agriculture Sector”. The overall objective is to promote food and nutrition security and to improve household incomes through coordinated interventions that will enhance sustainable agricultural productivity and value addition, provide employment opportunities and promote agribusinesses investments and trade (MAAIF 2013).

Uganda: Environment and Climate Change

National Climate Change Policy

The policy aims to ensure that all stakeholders with a role to play in the development of Uganda address climate change impacts and their causes through appropriate measures while promoting sustainable development (Ministry of agriculture animal industry and fisheries (MAAIF) and Ministry of water and environment (MWE), 2015).

National adaptation Programme of Action (NAPA)

The Program of Action contains 9 priorities focusing on building community and ecosystem resilience to adverse impacts of Climate Change (MWE 2007).

MAAIF plays a leading role in developing and promoting climate change policies. Other institutions—that include the Ministry of Finance, Planning and Economic Development (MoFPED) and the Ministry of Water and Environment (MWE)—also mainstream climate change adaptation and mitigation strategies into national policy frameworks.

Table 2 (continued)*Uganda: Land, Land use and Forestry*

Uganda Strategic Investment Framework for Sustainable Land Management (U-SIF SLM) 2010 – 2020

The goal of the Uganda Strategic Investment Framework (USIF) for SLM is to promote key sectors cooperation to improve natural resource-based livelihoods and other ecosystem services. The U-SLM SIF is a multi-sector (agriculture, water and environment, lands, energy and trade) national initiative spearheaded by MAAIF to implement the CAADP and TERR Africa (a partnership between FAO, World Bank, NEPAD and other implementing agencies for sharing lessons and developing tools and learning materials for scaling up and mainstreaming SLM). The U-SIF SLM aims at providing an integrated cross-sectoral approach to investing in solutions to crosscutting SLM challenges. It also aims at scaling up and mainstreaming SLM into the centre of the national development agenda (UNDP 2014).

Policy-makers and other stakeholders as listed in Table 3 on the whole need to implement a variety of measures to ensure that CA inputs and machinery are made more affordable and available to the farmers and collaborating stakeholders in the private sector. This has to do with local actualization of the trade policy and import duty tax on inputs like the rippers produced within Uganda; for example the direct seeders, two-wheeled tractors, spare parts and other raw materials for producing mechanisation equipment that are designed in Uganda like the Kabanyolo tractors for land preparation among other things that can be locally produced and easily availed to farmers.

High tariffs and long delays experienced during processing import machinery and other inputs also need to be lowered or at best removed. This would enable local repair shops and manufacturers to efficiently and effectively handle their customers, especially in the peak seasons. Additionally, when these trade barriers are addressed, just like credit and micro-credit institutions, these could altogether reduce their high interest rates so that farmers can access the necessary services to reasonably make more sustainable progress.

So far, there are limited studies on sustainability transition in general in Uganda, such as (Isgren and Ness 2017), and a few studies on CA in Africa, such as (Odhiambo et al. 2015). However, one of the key things central to sustainability transitions are power and politics (Kern and Markard 2016) because both factors greatly affect the overall nature of transformation. Due to vested interests of the stakeholders involved, there are winners and losers; for example, stakeholders can also form coalitions and alliances depending on their agenda and the amount of collective influence among themselves. Some of the CA stakeholders in Uganda laid out in Table 2 are already informally working together to some extent. Understanding political opinions and creating avenues for engagement and dialogue are important for the vision as (Martin et al. 2018) clearly illustrated.

3.7 Transition outcomes and impacts on the food system

The conventional agriculture regime is being challenged by the practices of the CA niche through minimum tillage, crop rotations and mulching or planting a permanent cover crop.

Table 3 Some of the stakeholders influencing CA transition in Uganda

	Government Institutions	Private sector organisations	Local governments	Parastatals
Actors	MAAIF Ngeta (NARO) Operation Wealth Creation (OWC)	Insurance Companies Financial Institutions Input dealers produce buyers Service providers Farmers' organisations, e.g. Uganda National Farmers Federation (UNFF), farmers' groups	Local Councils District Technical Departments	Development Partners Faith Based & Cultural Institutions, NGOs, civil society organisations (CSOs), community-based organisations (CBOs)
Services	Policy implementation Coordination Resource mobilisation Extension services Regulation Standards Early warning information Research	Provision of financial services, credit and banking services Provision of market Facilitation of group formation/ Savings and Credit Cooperative Organizations (SACCOs) Awareness, mobilisation Advocacy & coordination of partnerships Implementation of CSA activities Promotion of group marketing and warehouse receipt systems	Mobilise farmers' participation in CSA programs, plans	Contribution towards policy development Advocacy Capacity building Support implementation of CSA interventions
Interests	Research for development and innovations CSA knowledge, extension and agro-weather services Institutional coordination	Improved incomes & productivity Value chain integration	Budget and implementation of CSA	Financial support for development Build local capacity & implementation

When CA farmers get better yields and/or better survival crops during long dry spells among other benefits, their conventional agriculture counterparts would seek to follow suit.

Thanks to the self-help community groups that provide labour on a revolving group system, CA has also improved livelihood resilience. At the same time, CA has promoted diversification of income sources as extra money is invested in other off-farm ventures. Lastly but not least, the rural farm group members built trust among themselves as they collaborate and this further strengthened the indigenous community leadership structure headed by the village chief. One FGD respondent emphasised this below:

“Bad leadership is what brought” National Climate-Smart Agriculture (NCSA) task force, yet the area practices rain-fed agriculture. On the underside, infrastructures in the form of transport, irrigation, storage and value addition, machinery and poor market linkage still haunt the niche and thus compromise the overall economic performance.

With respect to the sustainability of the food system, the farmers, as one of the main actors of the CA initiative, have demonstrated changes as follows; they are more aware of landscape pressures such as climate change variabilities and others like land and soil degradation that require sustainable methods of farming. Their motivations are also based on the benefits observed on their lands particularly better yields in times of prolonged droughts and dry spells. Their expectations are also for more updated knowledge such as weed management, crop spacing in their agro-ecological zone, machinery acquisition and sharing options and value addition of their products among others.

3.8 Niche-regime interaction mechanisms and legitimisation process

CA niche in Uganda used the knowledge development and knowledge diffusion through networks as the innovation system functions to actively collaborate with the regime actors. Based on the work of (Elzen et al. 2012), the CA niche used the technological and network anchoring mechanisms in view of transforming the conventional agriculture. Second, the practice involves maintaining a crop cover through mulching or planting a cover crop that can double as animal fodder. This is also unlike the conventional practice where land is left bare, open or “naked”. CA farmers through their farmers’ groups access knowledge and farming services such as spraying and reduced tillage using the shared animal drawn ox plough. The farmer groups offer support for their members for on-farm problems, labour and knowledge sharing. Due to strong community relationships, farmers transformed their farming to CA. The new technical practice of CA involves digging permanent planting stations (Kaweesa et al. 2018; Mubiru et al. 2017), among others.

Lastly, the CA niche is also characterised by crop rotations unlike conventional agriculture that might be only monocrops every season. The second mechanism is “network anchoring”.

The main niche pioneers and supporters of CA included NGOs and donors that implemented and provided budgets for CA pilots and project demonstrations, respectively. The latter are also relevant in that they have power to dialogue with high-level stakeholders (this attitude perhaps arises from their ability to fund incentives) and better access to research, knowledge and technologies. Some of the support is perhaps in the interest of meeting international treaties and agreements.

The connection that the CA initiative is making across niches, regimes and the landscape is through the National Climate-smart Agriculture task force that is made up of various stakeholders that represent these three socio-technical levels. These include the CSA focal point from MAAIF together with senior agricultural officials, the FAO, CSOs and

NGOs implementing CA, NARO regional representatives, academia, private sector and UNDP.

Mechanisms used by the CA niche to anchor to regime included formation of partnerships and collaborations between several stakeholders within and outside Uganda and coordination to reduce duplication of efforts. There is high momentum of infrastructures such as the Africa Conservation Tillage network (ACT) and others that share research, best practices and CA experiences thus facilitating knowledge exchange between its members.

The NARO facilitates the adoption of CSA practices; Makerere University Centre for Climate Change Research and Innovations (MUCCRI) is a hub of academic, professional development and research excellence in climate science, climate adaptation and related disciplines; the Climate Change Department (CCD) is responsible for strengthening Uganda's implementation of the United Nations' Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP). The various bodies named above indirectly enhance the farmers' capacity to manage climate risks by developing context-suitable agricultural practices and sustainable value chains.

Political will in advancing the aims of the CA initiative will perhaps be evidenced by the budget allocated to cover initial high capitals that cannot be met by smallholder farmers, the enablement to mechanise. Since one of the challenges is the fake inputs on the market, if the relevant political authorities addressed these weak policy implementations that are under their jurisdiction, this might as well be a sign of political will. For the local artisans, the taxes on materials used for local agricultural machinery production could be waived in order to encourage mass production in the small local hubs. Markets would also be encouraged for the farmers to benefit from their products when sold at equitable prices if regulated fairly.

Based on the study of Montenegro (de Wit and Iles 2016), the CA niche is following a scientific mode of seeking legitimacy in the form of peer-reviewed publication of local research findings to validate the goal of the technology. The practice mode of legitimacy is also already in play through farmer adoption and sharing of knowledge. Other legitimisation processes include civic arenas through public awareness; policy and institution, for instance through the formation of National Climate-Smart Agriculture (NCSA) task force; engagement of the wider public through every possible avenue, for example the Uganda Faiths Network on Environmental Action (UFNEA), Foundations For Farming (FFF) and Farming God's Way (FGW) that are movements promoting the adoption of CA through raising awareness of their faithful followers. This borders with the ethics mode as the faithful believers centre their attention on the ethical legitimacy of the food production system.

Looking at the social pillar of the CA initiative, the niche contributes to improving food security through improved yields, informal knowledge enhancement through farmer field schools, exchange visits, field visit days, CA training workshops, CA pilots and demonstrations and labour opportunities, e.g. community service providers. It is also clear that the transition might be led by the community given the social context of the region as one FDG participants asserts below;

"The downfall of the Lango cooperative happened during that time the regime used to support the co-operative, but the current regime does not support it at all for the reasons we do not know. So, this new one that we have begun, we hear that the government is following it up very much either to support it or for some reason unknown to us. For us we started Abia cooperative deriving from Aterayong which was older but went away with the Lango cooperative."

During the focus group discussions, women reported support for one another, especially the widows and elders whom they helped to dig the basins or rip their pieces of land in

preparation for the planting season. Changes in practices have further revealed the gender societal rules; for instance, women stuck connected with their fellow women on sharing knowledge and information rather than approaching their male counterparts. CA women showed better group dynamics when left on their own. They also expressed themselves better that way.

On the ecological pillar, CA niche uses ecological production practices through soil and water conservation as met by all three CA principles. It is in line with water strategies for areas that experience water stress periods, and of late unreliable rainfall patterns. In the long run, it contributes to soil health by minimising soil disturbances. Also, it raises resilience capacity through enhanced ability to cope and adapt to climate change impacts. The country is already experiencing climate variabilities, Ssentongo et al. (2018).

Economically, the CA niche has more positive attributes including increase in yields and subsequent farm profitability, opportunity for off-farm investments and diversification. The niche also created jobs for youths and yet still generating financial capital.

4 Conclusions

Unlike many other previous sustainability transitions studies that are often criticised of being limited to the developed countries, this study is original as it takes place in the Global South. This serves to remove this bias and even more so the lack of methods in adoption studies in sub-Saharan Africa (SSA). Our study also adds value to adoption studies as it uniquely applies the MLP, unlike the other CA studies in Uganda and perhaps elsewhere. Learning from the transport and energy transition, as explicitly covered by the work of (Schot and Geels 2007; Geels and Schot 2007), there are several transition pathways. Nevertheless, in the past, agriculture took a reproduction process pathway; farmers practiced conventional agriculture and still got their yields. This locked the farmers into unsustainable methods of farming, as there was hardly any need to change. Our study reveals that farmers are capable and are making a transition to the state-of-the-art sustainable alternatives in remote or hard-to-reach areas in SSA. The case study results show that a leap transition is possible. Niches might not have to follow prescribed step-by-step procedures. Just like masses in SSA have mobile phones without necessarily having owned home telephones with masts, the same is possible with agricultural technologies in developing, non-OECD, countries. Landscape developments are in the process of exerting pressure on the regime and are already cracking down the system lock-in.

In general, technological change is indeed happening in several areas albeit sporadically in the country. The study reveals a new transition that is definitely shifting between the technological substitution and reconfiguration pathways in the Lango region. For farmer groups that received knowledge and training or even awareness, either directly or indirectly, CA has slowly replaced their conventional practices at farm level. This continues to happen as farmers realise benefits themselves through better yields and incomes, neighbours seeing plant growth differences between the CA fields and non-CA fields. This breakthrough will eventually replace the conventional agriculture regime. Landscape pressures could quicken the transition. More shifts can be expected in other hard-pressed areas such as those experiencing effects related to climate change, soil and environmental degradation. CA as a niche innovation can be expected to solve problems such as soil erosion and long dry spells that cause crops to dye prematurely, and for others it is a matter of belief. For the latter, this means sacredly doing farming, treating the soil and generally natural resources

with respect to believing that human beings are only custodians of these and that ultimate ownership lies beyond the physical realm.

When the high initial capital costs are covered by both the government as a social protection measure and by the private sector as a business case, there could be a demand for CA as doing farming would be eased due to drudgery reduction among other things that make the industry less attractive even to the unemployed. This could be a win–win situation albeit in the long term.

Further unlocking the potential of CA transition demands a power shift, and education is a good starting point. Infrastructure needs to be put in place to facilitate the transformation. The actors could pave a transition pathway by catalysing the power to change. There is demand for an interface with politics if the spick-and-span national documents and plans are anything to go by. Adoption of CA is site specific, and the adoption patterns across the country appear to be different. In Northern Uganda, CA adoption happened because farmers had access to information, and they were trained in the technique of CA. This could also be attributed to the history of the area that was marred by violence and conflict and so a lack of trust of external activities related to government programs. The farmers were ready to take on technologies only after they had clearly understood how CA works and how it would help them improve their livelihoods. This is a positive sign because state of the art information is necessary for transformation to occur.

The policies that are needed to favour CA development in Uganda include the National Land Use Policy for Uganda (2008), CSA and SLM policy, Agriculture Policy (2013), climate change policy and the National Agricultural Research (NAR) policy (2003). The policy recommendation would be to target the whole agricultural chain as a more feasible pathway. However, coordination of stakeholders and restructuring to reduce on unnecessary staff costs and avoid duplication can be a means of redirecting political power to bring about transition. As the most important documents are available at national level, these need technocrats to implement without or at least less interference of political interest. Dissemination of information remains pivotal for the transition; linkages between farmers' groups, researchers and extension agents are vital. CA is a long-term strategy and so investment in the sector needs to be done in the same manner.

Acknowledgement The PhD studies are/were financed by the Austrian Partnership Programme in Higher Education and Research for Development—APPEAR, a programme of the Austrian Development Cooperation (ADC) and implemented by the Austrian Agency for International Cooperation in Education and Research (OeAD).

Funding Open access funding provided by University of Natural Resources and Life Sciences Vienna (BOKU).

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

Appendix: Key informant interview guide

Self-introductory remarks

Key informant interviews will generate information on the general outlook of CA in the region and the historical agricultural context of the area. Some of the interviewees will include community elders, local traditional chiefs, historians and experts such as academia on the region, district Local Government officials and technical staff and representatives from FAO, MAAIF and Farmer Field School among others. This information will provide some input into the MLP theoretical framework. There will be a minimum of six and up to ten interviews. The overall **objective of the exercise is to** explore and determine the impact/role of stakeholder contribution (combinations of) to the uptake, scaling up or refusal to take up and scaling up of CA among selected farmer typologies.

Research questions:

- i. Does CA adoption depend on sociocultural factors in the communities where it is promoted?
- ii. What are the institutional processes that determine CA adoption in Northern Uganda?
- iii. What are the institutional factors that might be relevant for a socio-technical transition in CA adoption in Uganda?

Questions to guide interview

1. When did CA start in Dokolo? Who are some of the key service providers for CA? And what are their roles?
2. Are farmers given any incentives or assistance to enable them do CA? What type of farmer is likely to adopt the practice? If they were never given any incentives, would they still do CA?
3. What factors are hindering taking up of CA as a technology; does government have a budget marked for doing CA?
4. What would be necessary for a long-term shift in attitudes and perceptions necessary for accelerating CA scaling up?
5. What are some of the sociocultural issues that need to be addressed for uptake of CA?
6. What are the institutional changes that are needed to promote CA?
7. Are there any key political challenges affecting replication and diffusion of the CA technology? If so, how can they be addressed?
8. Are the power structures in the area sufficient for transformation in agriculture to take place?
9. What do you foresee as a future challenge for scaling up technologies? How can it be backstopped?
10. Is there any additional information that you would like to highlight for the study?

References

- Andersson, J. A., & D'Souza, S. (2014). From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa. *Agriculture, Ecosystems & Environment*, 187, 116–132.
- Baudron, F., Thierfelder, C., Nyagumbo, I., & Gérard, B. (2015). Where to target conservation agriculture for African smallholders? How to overcome challenges associated with its implementation? Experience from Eastern and Southern Africa. *Environments*, 2, 338–357.
- Bilali, E. L. (2018). *H* (pp. 1–36). Development and Sustainability: Transition heuristic frameworks in research on agro-food sustainability transitions. Environment.
- Bilali, E. L. J. H. (2019a). Research on agro-food sustainability transitions: A systematic review of research themes and an analysis of research gaps. *Journal of Cleaner Production*, 221, 353–364.
- Bilali, E. L. H. (2019b). The multi-level perspective in research on sustainability transitions in agriculture and food systems: A systematic review. *Agriculture*, 9, 74.
- Bold, T., Kaizzi, K. C., Svensson, J., & Yanagizawa-Drott, D. (2015). *Low quality, low returns, low adoption*. London School of Economics, International Growth Centre, London: Evidence from the market for fertiliser and hybrid seed in Uganda.
- CIAT & BFS/USAID (2017). Climate-Smart Agriculture in Uganda. In: Andreea Nowak (CIAT), Sebastian Grey (CIAT) and Miguel Lizarazo (CIAT) (ed.). Washington, D.C.
- Corbeels, M., de Graaff, J., Ndah, T. H., Penot, E., Baudron, F., Naudin, K., et al. (2014). Understanding the impact and adoption of conservation agriculture in Africa: A multi-scale analysis. *Agriculture, Ecosystems & Environment*, 187, 155–170.
- Corbeels, M., Thierfelder, C., & Rusinamhodzi, L. (2015). *Conservation agriculture in sub-Saharan Africa. Conservation agriculture*. Cham: Springer.
- Darnhofer, I., Gibbon, D., & Dedieu, B. (eds.) (2012). *Farming systems research into the 21st century: the new dynamic*: Springer Science & Business Media.
- De Wit, M. M., & Iles, A. (2016). Toward thick legitimacy: Creating a web of legitimacy for agroecology. *Elem Sci Anth*, 4.
- Dregne, H. E. (1990). Erosion and soil productivity in Africa. *Journal of Soil and Water Conservation*, 45, 431–436.
- EL Bilali, H., Hauser, M., Berjan, S., Miseckaite, O., & Probst, L. (2017) Rural livelihood transitions: Towards an integration of the sustainable livelihoods approach and the multi-level perspective. In: the 8th international scientific conference “Rural Development 2017: Bio-economy Challenges”; November 23–24., 2017 2017 Kaunas, Lithuania, pp. 1010–1016.
- Elzen, B., van Mierlo, B., & Leeuwis, C. (2012). Anchoring of innovations: Assessing Dutch efforts to harvest energy from glasshouses. *Environmental innovation and societal transitions*, 5, 1–18.
- FAO. (2015). *Conservation Agriculture* [Online]. <http://www.fao.org/conservation-agriculture/en/>. [Accessed July 23, 2018 2018].
- FAO, Food. (2010). Climate smart agriculture: policies, practices and financing for food security, adaptation and mitigation. In *Paper prepared for Hague Conference on Agriculture, Food Security and Climate Change*.
- Friedrich, T., Derpsch, R., & Kassam, A. (2012). Overview of the global spread of conservation agriculture. *Field Actions*, 6.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31, 1257–1274.
- Geels, F. W. (2006). Co-evolutionary and multi-level dynamics in transitions: the transformation of aviation systems and the shift from propeller to turbojet (1930–1970). *Technovation*, 26, 999–1016.
- Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, 39, 495–510.
- Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation And Societal Transitions*, 1, 24–40.
- Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography*, 24, 471–482.
- Geels, F. W. (2018a). Disruption and low-carbon system transformation: progress and new challenges in socio-technical transitions research and the multi-level perspective. *Energy Research & Social Science*, 37, 224–231.
- Geels, F. W. (2018b). Low-carbon transition via system reconfiguration? A socio-technical whole system analysis of passenger mobility in Great Britain (1990–2016). *Energy Research & Social Science*, 46, 86–102.

- Geels, F. W. (2018c). Socio-technical transitions to sustainability. *Oxford Research Encyclopedia of Environmental Science*.
- Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, 36, 399–417.
- Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. *Field Crops Research*, 114, 23–34.
- Grin, J., Rotmans, J., & Schot, J. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*, Routledge.
- Hall, A., & Clark, N. (2010). What do complex adaptive systems look like and what are the implications for innovation policy? *Journal of International Development: The Journal of the Development Studies Association*, 22, 308–324.
- Hauser, M., & Lindtner, M. (2017). Organic agriculture in post-war Uganda: Emergence of pioneer-led niches between 1986 and 1993. *Renewable Agriculture and Food Systems*, 32, 169–178.
- Hobbs, P. R., Sayre, K., & Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 363, 543–555.
- Isgren, E., & Ness, B. (2017). Agroecology to promote just sustainability transitions: analysis of a civil society network in the rwenzori region, Western Uganda. *Sustainability*, 9, 1357.
- Kassam, A. H., Mkomwa, S., & Friedrich, T. (2017). *Conservation agriculture for Africa: building resilient farming systems in a changing climate*. UK, CABI: Wallingford.
- Kaweesa, S., Mkomwa, S., & Loiskandl, W. (2018). Adoption of Conservation Agriculture in Uganda: A Case Study of the Lango Subregion. *Sustainability*, 10, 3375.
- Kern, F., & Markard, J. (2016). *Analysing energy transitions: combining insights from transition studies and international political economy. The Palgrave handbook of the international political economy of energy*. London: Springer.
- Kuteesa, A., Kisaame, K. E. & Barungi, J. (2018). Public expenditure governance in uganda's agricultural extension system.
- Lachman, D. A. (2013). A survey and review of approaches to study transitions. *Energy Policy*, 58, 269–276.
- MAAIF (2013). The National Agricultural Policy. In: MINISTRY OF AGRICULTURE, A. & FISHERIES, I. A. (eds.). Kampala.
- MAAIF (2015). Ministry of agriculture animal industry and fisheries, Ministry of water and environment. 2015. Uganda climate smart-agriculture country program 2015–2025. Kampala.
- MAAIF (2016). Agriculture sector strategic plan. In: MINISTRY OF AGRICULTURE, A. I. A. F. (ed.).
- Markard, J., & Truffer, B. (2008). Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy*, 37, 596–615.
- Martin, G., Allain, S., Bergez, J.-E., Burger-Leenhardt, D., Constantin, J., Duru, M., et al. (2018). How to address the sustainability transition of farming systems? A conceptual framework to organize research. *Sustainability*, 10, 2083.
- Mbowa, S., Luswato, K. C. & Bulegeya, K. (2015). Are ugandan farmers using the right quality inorganic fertilizers?
- Mbowa, S., & Mwesigye, F. (2016). The seed potato gap in Uganda: an investment opportunity, and a challenge for value addition.
- Ministry OF Agriculture Animal Industry and Fisheries (MAAIF) & Ministry OF Water AND Environment (MWE) (2015). Uganda climate smart-agriculture country program 2015–2025. Kampala.
- Mubiru, D. N., Namakula, J., Lwasa, J., Otim, G. A., Kashagama, J., Nakafeero, M., et al. (2017). Conservation farming and changing climate: more beneficial than conventional methods for degraded ugandan soils. *Sustainability*, 9, 1084.
- Mutyaba, C., Lubinga, M. H., Ogwal, R. O., & Tumwesigye, S. (2016). The role of institutions as actors influencing Uganda's cassava sector. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 117, 113–123.
- MWE (2007). Uganda National Adaptation Programmes OF ACTION. In: Environment, M. O. W. A. (ed.). Kampala.
- NEPAD (2003). NEPAD: Comprehensive Africa Agriculture Development Programme (CAADP). Madrand, South Africa: New Partnership for Africa's Development (NEPAD)
- Nkonya, E., Kaizzi, C., & Pender, J. (2005). Determinants of nutrient balances in a maize farming system in eastern Uganda. *Agricultural Systems*, 85, 155–182.
- Nyende, P., Nyakuni, A., Opio, J. P., & Odogola, W. (2007). *Conservation agriculture: a Uganda case study*. Rome: FAO.
- Odhiambo, J. A., Norton, U., Ashilenje, D., Omondi, E. C., & Norton, J. B. (2015). Weed dynamics during transition to conservation agriculture in western Kenya maize production. *PLoS ONE*, 10, e0133976.

- Pan, Y., Smith, S. C. & Sulaiman, M. (2018). Agricultural extension and technology adoption for food security: Evidence from Uganda. *American Journal of Agricultural Economics*.
- Schot, J., & Geels, F. W. (2007). Niches in evolutionary theories of technical change. *Journal of Evolutionary Economics*, 17, 605–622.
- Scoones, I., Leach, M., Smith, A., Stagl, S., Stirling, A. & Thompson, J. (2007). Dynamic systems and the challenge of sustainability.
- Smith, A. (2007). Translating sustainabilities between green niches and socio-technical regimes. *Technology Analysis & Strategic Management*, 19, 427–450.
- Smith, A., Voß, J.-P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, 39, 435–448.
- Ssentongo, P., Muwanguzi, A. J. B., Eden, U., Sauer, T., Bwanga, G., Kateregga, G., et al. (2018). Changes in Ugandan climate rainfall at the village and forest level. *Scientific Reports*, 8, 3551.
- Sutherland, L.-A., Darnhofer, I., Wilson, G., & Zagata, L. (2014). *Transition pathways towards sustainability in agriculture: case studies from Europe*, CABI.
- Thierfelder, C., Matemba-Mutasa, R., Bunderson, W. T., Mutenje, M., Nyagumbo, I., & Mupangwa, W. (2016). Evaluating manual conservation agriculture systems in southern Africa. *Agriculture, Ecosystems & Environment*, 222, 112–124.
- UBOS. (2017). *Statistical abstract;uganda bureau of statistics*. Uganda: KAMPALA.
- UBOS. (2018). *Statistical abstract*. Uganda: Kampala.
- Uganda. Ministry of Agriculture, A. I. A. F., & Uganda. Ministry of Finance, P. A. E. D. (2000). *Plan for Modernisation of Agriculture: Eradicating Poverty in Uganda: Government Strategy and Operational Framework*, Ministry of Agriculture, Animal Industry and Fisheries
- UNDP (2014). *Uganda Strategic Investment Framework for Sustainable Land Management 2010-2020*. Kampala.
- Vaiknoras, K., Norton, G., Alwang, J. R., & Taylor, D. (2014). Preferences for Attributes of Conservation Agriculture in Eastern Uganda.
- Von Grebmer, K., Bernstein, J., Patterson, F., Wiemers, M., Chéilleachair, R. N., Foley, C., Gitter, S., Ekstrom, K., & Fritschel, H. (2019). 2019 global hunger index: the challenge of hunger and climate change (No. 329-2016-13171).

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.