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Food Security in Sub-Saharan Africa: A Fresh Look on Agricultural Mechanisation

How adapted financial solutions can make a difference

Christiane Ströh de Martínez
Marietta Feddersen
Anna Speicher

Food security in sub-Saharan Africa:
a fresh look on agricultural mechanisation

The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) is a multidisciplinary research, policy advice and training institute for Germany's bilateral and multilateral development cooperation. On the basis of independent research, it acts as consultant to public institutions in Germany and abroad on current issues of cooperation between developed and developing countries. Through its nine-month training course, the German Development Institute prepares German and European university graduates for careers in the field of development policy.

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Preface

This study has been written in the frame of two DIE research projects. The first is “Promoting food security in rural sub-Saharan Africa: the role of agricultural intensification, social security and results-oriented approaches”, which is being funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) under its special initiative “One World, No Hunger” (SEWOH). The second project is “Mobilising capital for sustainable development”, which is also being funded by the BMZ.

In the project “Promoting food security in rural sub-Saharan Africa”, special emphasis is put on the role of sustainable agricultural intensification and social security to promote food security while recognising that different approaches may be needed in fragile state contexts. It is explicitly acknowledged that the rural populations are not homogeneous and have differentiated development potentials and support needs (Rural Worlds). In line with the aid effectiveness agenda, the project also explores how the results orientation of food security interventions can be improved.

The topics are allocated across eight working packages:

1. Conceptual framework: sustainable food security in rural sub-Saharan Africa
2. Agricultural growth corridors within the New Alliance for Food Security and Nutrition
3. Agro-ecological support of subsistence-oriented farms
4. Agricultural investments and finance in small-scale agriculture
5. Promoting irrigated agriculture
6. Social security systems, food security and long-term development
7. Fragility and its interaction with sector approaches to combating hunger
8. Results-based approaches and results-based management

The project “Promoting food security in rural sub-Saharan Africa” seeks to cross the barriers between the different sectors and academic fields and to derive broader insights and recommendations on food security in rural areas. Cooperation is sought with other research organisations funded within the SEWOH initiative, with universities and think tanks, with projects of

German development cooperation, with international organisations such as the International Fund for Agricultural Development and the World Bank, with civil society and the private sector. Results are spread through high-quality research papers and studies, policy briefs and opinion texts, electronic media, conferences, seminars and workshops. In this context and fully in line with the special initiative (SEWOH) of the BMZ, the DIE and the GIZ Sector Project “Agricultural Trade and Value Chains” launched a cross-sectoral knowledge platform on agricultural finance in March 2016. The national knowledge platform AgriFiP (“Agricultural Finance in Practice”) is designed to bridge existing gaps in communication, coordination and implementation between the agricultural and financial sectors on tailor-made financial services for agricultural clients. The knowledge platform’s focal point does not limit itself to a cross-sectoral and multi-level approach. AgriFiP defines its scope through the deliberate incorporation of practitioners in the entire dialogue, and thus makes an important difference to other existing platforms and working groups. It is hoped that in this way the project can make an important contribution to the German and international agenda for creating a world without hunger.

The project “Mobilising capital for sustainable development” examines how the quantity and quality of capital for financing the 2030 Agenda can be enhanced. The project has two research strands. The first strand focusses on international trade and investment regimes and their consequences on developing countries. The second strand, within which this study was written, focusses on innovative approaches for financing sustainable development, including for instance green bonds, local currency bond market development and, notably, value chain finance. The project also seeks to identify measures to improve the regulatory and policy environments in developing countries in a way that allows for mobilising higher levels of capital for investment. The identification of such measures is also a central concern of the study “Food security in sub-Saharan Africa: A fresh look on agricultural mechanisation. How adapted financial solutions can make a difference”.

Michael Brüntrup and Lisa Wegner
German Development Institute /
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Our special thanks are extended to the expert “community of practice” who participated in two project workshops. Experts came from the German Federal Ministry for Economic Development and Cooperation (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and the German Development Bank (KfW). Their advice and comments have been a great help in determining the study’s focus areas.

A larger group of experts and practitioners around the world in the financial sector and the field of agricultural development shared their invaluable knowledge and experience through a range of expert interviews. The list of persons we spoke to is provided in Annex 1.

Furthermore, we are particularly grateful for the support provided by Dr Susanne Neubert, Dr Paul Armbruster, Dr Frank Höllinger and Prof. Dr Manfred Nitsch, who provided their valuable time and professional expertise for a detailed review of our study and many useful comments. Assistance and important specialist agronomic advice from Ingrid Hartmann has been a great help throughout this research. Moreover, we are very grateful for the important support provided by Pauline Asbrand with background research and elaboration of the case studies.

July 2016

Dr Christiane Ströh de Martínez
Marietta Feddersen
Anna Speicher

Contents

Preface

Acknowledgements

Abbreviations

Executive Summary	1
1 Introduction: the food security challenge and the promise of financing mechanisation	11
2 The context for mechanisation and agricultural finance: complex rural livelihoods in SSA	20
3 Mechanisation in SSA and its implications for food security	32
3.1 Understanding mechanisation in SSA	32
3.2 Barriers to successful mechanisation in SSA	39
3.3 Intended and unintended consequences for food security: how can mechanisation have a positive impact?	49
3.3.1 Effects on people and land	49
3.3.2 Implications for food security	62
3.4 Success factors for sustainable mechanisation	69
4 Financing mechanisation – challenges and solutions	73
4.1 Financing mechanisation must be guided by commercial principles	75
4.2 The demand-side of financing mechanisation	78
4.2.1 Farmers have diverse and complex financial management needs	78
4.2.2 Constraints of farmers in accessing financial services for mechanisation	83
4.2.3 Alternative business models for individual ownership of machinery exist	86
4.3 The supply side of financial services for mechanisation	88
4.3.1 Supply-side challenges to provide financing for mechanisation	89

4.3.2	Various financial products can enable mechanisation	92
4.3.3	Landscape of financial service providers	105
4.3.4	Cost-effective distribution channels for financial services are key to scale	108
4.4	Success factors and guiding principles for mechanisation finance	111
5	Conclusion	114
	References	123

Annexes

	Annex 1: List of interview partners	143
	Annex 2: Case studies	149
1	myAgro: Targeted savings with innovative distribution channels	149
2	FACASI: Innovative business models for machinery distribution and supplementary services in SSA	152
3	Pedal Pump: Improved irrigation techniques can increase yields and reduce drudgery	154
4	AccessBank: “Agri-loan” takes irregular income and expenditure patterns of smallholders into account	156
5	Graduation programme: Promoting farm and non-farm income-generating activities to reduce poverty and improve people’s livelihoods	158
6	CUMA: Benin farmers show how mechanisation can be financed in the absence of financial services through a cooperative scheme	160
7	NWK Agri-Services: Agribusiness companies can facilitate sustainable mechanisation	162
8	Hello Tractor: The use of new technologies for innovative tractor-hiring services in Nigeria	165
9	DCFU leasing: Agricultural leasing products can provide farmers who lack collateral with a chance to mechanise their production	167
10	Kafo Jiginew: A credit cooperative in Mali offers a special-designed agricultural equipment loan to low-income clients	170

Figures

Figure 1: Yield gap, availability of uncultivated land and area cultivated per inhabitant in selected sub-Saharan African countries	12
Figure 2: Impact hypothesis	19
Figure 3: Risk profile of rural households in SSA	24
Figure 4: Tasks in the agricultural value chain that can be found on-farm or off-farm	33
Figure 5: African developing countries by farm power (2002)	38
Figure 6: Farming systems in Africa	40
Figure 7: Tsetse fly and cattle distribution in Africa	42
Figure 8: Influences of mechanisation on food security for agricultural households	64
Figure 9: Financial management needs according to the five Rural Worlds	82
Figure 10: Constraints in accessing financial services	85
Figure 11: Overview of a typical outgrower scheme	110

Tables

Table 1: Intensities of mechanisation	34
Table 2: Number of tractors in use	36
Table 3: Number of tractors per 100 km ² of arable land in selected countries / regions	37
Table 4: Sources of farm power for land preparation (% of total)	37
Table 5: Financial management needs of family-led farms	80
Table 6: Overview of access to agricultural credit against core economic figures in selected countries	88
Table 7: Intensities of mechanisation and suitable financial products per RW to buy a machine	104
Table 8: NWK agricultural services	164

Abbreviations

ACGSF	Agricultural Credit Guarantee Scheme Fund
BMZ	German Federal Ministry for Economic Cooperation and Development / Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
CA	Conservation Agriculture
CIMMYT	International Maize and Wheat Improvement Center / Centro Internacional de Mejoramiento de Maíz y Trigo
CUMA	Coopérative d'Utilisation de Matériel Agricole
DIE	German Development Institute / Deutsches Institut für Entwicklungspolitik
DFCU	Development Finance Company of Uganda
DFS	Digital Financial Services
FACASI	Farm Mechanisation and Conservation Agriculture for Sustainable Intensification
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ha	Hectare
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
KfW	German Development Bank / Kreditanstalt für Wiederaufbau
MFI	Microfinance Institution
MIS	Management Information System
NGO	Non-governmental Organisation
OECD	Organisation for Economic Co-operation and Development
RW	Rural World
SME	Small and Medium-sized Enterprise

SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
VAT	Value-added Tax
2WT	Two-wheeled Tractor

Executive Summary

Much of sub-Saharan Africa's farmland is (still) cultivated with the hand hoe, and agricultural processing and transport are often done manually. This limits the potential of agriculture in the region and the attractiveness of agriculture and its value chains for the young generation. One important improvement could be the mechanisation of (parts of) the production processes. However, this implies high levels of investment and risks for farmers, and the necessary financing is especially difficult to access for longer-term agricultural investments such as mechanisation. In addition, there can be trade-offs between mechanisation and employment for and of the poor. For a better understanding of how mechanisation can contribute to food security, we first assess the non-financial aspects of mechanisation. In a second step, the difficulty in accessing financing is analysed, distilling success factors for financing mechanisation.

Motivations for this study: the food security crisis, mechanisation as a promising remedy and access to finance as its key barrier

Sub-Saharan Africa (SSA) faces the challenge of chronic food insecurity, with an estimated 23.2 per cent of its population being food insecure. Current demographic and climatic changes will further exacerbate the region's food security crisis. Most of SSA's hungry live in rural areas and are involved in agricultural activities for subsistence or income generation, and are dependent on often disconnected local food markets. Hence, food security of a large share of the population depends directly or indirectly on increasing agricultural production on the individual, local and regional levels. Agriculture in SSA is characterised by mostly small- to medium-scale family-led farms that rely almost entirely on manual labour for most farm tasks. In a context of short rainfall seasons, this often leads to labour bottlenecks at critical points in the cropping cycle, resulting not only in a limitation of cropping area per household, but also in extremely low productivity rates. High levels of food loss in production – but also in processing, storage and transport – aggravate the situation. Mechanisation promises to increase productivity and production levels by filling the power gap in rural SSA and reducing post-harvest losses. As a result, more food could be produced locally, and the availability of and access to

food may be increased, especially for the rural populations. Despite these chances, however, mechanisation also entails additional risks, particularly for smallholder farmers and poorer households through lost employment opportunities or higher dependency and inequality structures. For these reasons, “abolishing” the hand hoe and mechanising farming is one of the key priorities of the African Union.

One of the biggest challenges for successful mechanisation in rural SSA today is access to finance. Financing mechanisation falls into the field of agricultural finance. It is, however, not a distinct conceptual category in itself, whereas no numbers exist for the (lack of) financing for mechanisation, and very little data is available to document the amount of finance provided to the agricultural sector.¹ Data on overall credit provision in rural regions in SSA indicate a low penetration of financial services, with often less than 10 per cent of farmers having access to a loan.²

Financing mechanisation is challenging for farmers and financial institutions alike. For most farmers and rural households, the purchase of agricultural machinery is a huge investment when considering their income flows. Therefore, aspects of the economic viability of such an investment need to be considered particularly carefully. Mechanisation assets beyond the level of a hand tool typically require lumpy investments, which only pay off when used to the economic potential of a machine – that is, by deploying it on a sufficiently large agricultural operating area or by maximising the machine’s economic value through multipurpose use patterns. Financial service providers, in turn, often see the agricultural (smallholder) sector as being particularly risky and too expensive to serve. They need to understand better the particularities of agricultural production and value

-
- 1 No sizeable disaggregated data on the supply of fixed-asset finance in SSA are available. Available data on purpose of agricultural finance mostly lists seeds, fertilisers and paying for farm labourers (see FinScope, 2013a, 2013b, among others). Short average loan sizes in rural finance data support this assumption (Steinwand, 10/2015).
 - 2 The several FinScope studies reveal access data for rural versus urban areas, but access to agricultural credit is often not available, as many financial institutions do not distinguish this category in their Management Information System (MIS). One telling dataset from Tanzania shows, however, what experts confirmed in the various interviews: the 2013 FinScope study revealed that 27.6 per cent of rural inhabitants have access to formal banking services, but only 7.1 per cent of agribusinesses are stated to have such access (FinScope, 2013b).

chain dynamics – including production and harvest cycles and their related cost-income streams – in order to provide adapted and affordable financial solutions. In addition, other aspects come into play that constrain access to finance for machinery or agriculture as a whole, including the farmers' lack of a proper financial education and the insufficient outreach of financial service providers into remote rural areas.

Since mechanisation involves both the agricultural and financial sectors, a close knowledge exchange between practitioners and experts between these sectors is necessary to make such investments successful. The present study seeks to facilitate such knowledge exchange: it offers a comprehensive overview of agricultural and financial sector expertise alike by assessing and explaining:

- The context for mechanisation in SSA: analysing relevant contextual factors of SSA's rural livelihood systems;
- The non-financial aspects of mechanisation: presenting the status quo of and current on-farm constraints for mechanisation in SSA and showing its sometimes ambiguous effects on food security in rural SSA;
- The financial aspects of mechanisation: offering a comprehensive analysis of supply- and demand-side challenges in financing mechanisation, and pointing to suitable financial solutions.

The context for mechanisation and agricultural finance

In this study, we try to account for the great diversity of rural livelihoods in SSA by using the Organisation for Economic Co-operation and Development's (OECD) typology of the five Rural Worlds (RWs) as a conceptual framework. Although some rural inhabitants run large commercial agricultural enterprises (RW 1) or operate small to medium-sized agricultural enterprises with a clear market orientation (RW 2), the majority of the rural populations comprise smallholder farmers with varying degrees of commercially used surplus production (RW 3). Some households are landless and have very little income, being entirely dependent on hiring out their labour (RW 4). Many of the households from both RW 3 and RW 4 are currently net food consumers. The group of chronically poor (RW 5) is hardly economically active and depends on external assistance. Most sub-Saharan African households in these RWs live in an environment of high

vulnerability to economic, climatic and social risks – with little or no formal safety nets, thus often relying on family-based safety nets. Therefore, most households employ strategies of on- and off-farm income diversification, shifting resources between household and farm.

In this setting, mechanisation offers opportunities for productivity gains and risk mitigation of individual farms. Yet, mechanising also requires a certain degree of commercialisation and specialisation, which is likely to increase certain risks. Hence, also given the absence of strong market linkages and insurance mechanisms, rural households might rationally decide not to mechanise. Financial solutions offered to farmers will have to take these constraints into account and include measures for reducing the particular risks inherent to mechanisation.

Non-financial aspects of mechanisation: how mechanisation affects food security

We embrace a broad understanding of mechanisation in our study, both in scope and intensity. Mechanisation can transform the working process along all steps of the value chain: production, processing, storage and transport. On each of these steps, mechanisation can happen in varying intensities, including not only high-intensity machinery such as tractors, but also low-intensity, specialised hand tools or medium-intensity mechanisation options such as draught animals or two-wheel tractors (2WTs).

Mechanisation affects agricultural and post-harvest processes in many ways. Importantly, mechanisation can improve the quality of life for farmers by reducing drudgery or raising the attractiveness of farm work, and thus contributing towards slowing down the rural-urban migration flows. Yet, the most important lever for mechanisation is increases in the productivity of labour, that is, output per worker, in particular where arable land is still available and where the potential for an expansion of crop area exists through the breaking of labour bottlenecks. Mechanisation also affects the productivity of land, that is, yields per hectare, resulting mainly from increases in the timeliness of field operations and the use of irrigation. These effects on productivity and production translate into the according income effects for those agricultural households directly involved in mechanisation. Where higher production results in a need for further value addition, storage or transport, it also offers additional

employment opportunities. However, empirical evidence has shown that mechanisation may also have negative distributional effects, as it may enable and incentivise land consolidation and displacement as well as lead to the unemployment of those in rural areas who are excluded from the benefits of mechanisation. Since agricultural work is often divided along gender lines in SSA, mechanisation also affects gender relations and may have both positive and negative effects on women. For example, although the mechanisation of labour- and time-intensive tasks may lower women's work burden, mechanising land preparation may lead to an increase in the household's cropping area, leaving more work for subsequent tasks such as weeding that are often traditionally carried out by women. Environmental effects are equally ambiguous, depending largely on a variety of contextual factors, and are therefore not easy to generalise and predict. Literature suggests that although high-intensity mechanisation can be an important source of rural employment, it also seems to hold more potential for adverse effects such as rural unemployment, displacement or deforestation, whereas adapted low- and medium-intensity machinery might offer a more equitable approach with less ecological intrusion. Finally, the degree of mechanisation not only depends on on-farm and agricultural considerations, but also on the relation with off-farm employment and structural change that allows many farmers to leave the sector while allowing some to invest and grow.

These agronomic and income effects translate more or less directly into effects on food security, especially on the access, availability, and stability pillars. Where mechanisation-induced increases in agricultural productivity lead to higher output in food crops, it may immediately increase local availability of – and physical access to – food for the whole community. In the case of non-food cash crops, increases in labour productivity can lead to more income for the households involved in the value chain. Moreover, the mechanisation of processing, transport and storage can reduce post-harvest losses and increase stability of food supply over time, for example where food mills or appropriate storing facilities make perishable food more durable. Where incomes are rising due to mechanisation, economic access to food increases, too; unemployment, on the other hand, will negatively affect the access component of food security.

From the above analysis, some success factors for mechanisation emerge:

- Technology needs to be adapted not only to farm size, but also to other contextual factors such as soils, availability of labour, land, water, knowledge, etc.
- Only demand-driven and profitable mechanisation has positive effects, as farmers need to be able to sustain their mechanisation by generating income and paying for operating and maintenance costs. This requires viable business models for various mechanisation options and farming systems.
- An enabling environment needs to be created that includes technical, business and financial training; favourable taxes and duties; as well as infrastructure for (spare part) supply and repair services.
- The overall balance of the effects of the pros and cons of mechanisation must include not only those farms that mechanise, but also the other RWs that are indirectly affected.

Financial aspects of mechanisation – well-tailored financial solutions are key

In the past, efforts to finance mechanisation have followed a state-led, strongly subsidised approach. Most of these interventions proved unsustainable, and lessons learnt have led to a paradigm shift over the last three decades towards a market-oriented approach.

Under this market-oriented approach, a variety of business models are suitable to foster mechanisation, but their applicability varies among the different RWs. Private ownership of big machinery is more feasible for farmers in RW 1 (and sometimes 2). Co-ownership models under cooperative schemes have potential, yet they show severe governance and organisational deficiencies in much of SSA. Shared-usage models – for example, in the form of outgrower schemes and contract farming, whereby a large farm allows use of its machinery by smallholders against a pre-agreed harvest participation – are promising, although the conditions have to be scrutinised to avoid abuse of smallholders. Lastly, machinery service providers have proven very successful in Asia and elsewhere and are emerging in SSA as a promising option to offer access to hired machinery for farmers in RWs 2, 3 and 4.

Financing mechanisation is challenging because it requires lumpy upfront investments, which normally amortise over several years and typically require medium-term finance products (e.g. loans or leasing), unless farmers have a very strong cash flow. Under the typical difficult framework conditions of SSA, lumpy investments pose a challenge – both for financial institutions as well as for farming enterprises or rural households.

On the demand side, farmers from RWs 2, 3 and 4 typically do not separate business and household financial needs, as both units are closely interwoven. In contrast, farmers in RW 1 and partly 2 require only business-related financial services. To translate their financial needs into access, farmers will have to overcome two types of constraints. Firstly, there are constraints that prevent a need from being translated into a demand. These include low levels of business and financial literacy, so people may not know which financial product they need – meaning they have a need but do not how to express this to a financial service provider. Secondly, there are constraints that prevent a farmer or family from translating a demand into access. These are, for example, high transaction costs due to long distances to financial institutions or limited availability of classical bankable collateral such as formal land titles. So although there is a clear need, the suitable financial services cannot be accessed.

On the supply side, the most important constraint preventing financial services from being offered to rural areas in SSA is the high transaction cost associated with reaching out to remote clients. Additionally, the perceived risk related to investment in agriculture is high, especially if the sector is not well understood by financial institutions. Furthermore, some financial institutions that are oriented towards rural clients face challenges in managing their liquidity and accessing long-term refinancing in order to realise larger and longer-term loans that are typical of mechanisation finance.

A number of interesting financial and non-financial innovations exist that have good potential to ease demand- and supply-side constraints for mechanisation finance: shared ownership models or machinery hiring services are gaining popularity. Leasing is a promising option and (in theory) a typical financial product for mechanisation. But it can often not be scaled-up due to basic legal bottlenecks, such as prohibitive tax regimes or ownership legislation, in most sub-Saharan African countries. Insurance is a

good enabler in high-risk environments, but, for example, asset insurance is only financially viable for large machines. Other insurance instruments such as weather index insurance can help farmers to manage performance risks when making use of machines. Targeted savings are helpful for financing low-intensity and low-cost mechanisation but have their limits in financing larger machinery. Mechanisation that falls in between the low-cost and very expensive solutions is the most difficult to finance. Alternative distribution channels for financial products are an important possibility for reducing transaction costs and enabling farmers' access to finance – such as value chain finance, nucleus outgrower schemes and direct supplier credits from machinery dealers.

A number of guiding principles for agricultural machinery finance can be highlighted:

- The underlying economic viability of a new machine for a farm needs to be assessed carefully to ensure that the investment can be repaid in the first place. Next to loans, leasing and insurance solutions can facilitate machinery finance (although difficult to implement). Ideally, a range of financial products should be available that can complement each other.
- To allow for suitable risk assessment and management, financial service providers should understand their customers and include agronomic expertise into their client analysis and underwriting procedures.
- Aggregation of farmers can facilitate intermediation and a reduction of transaction costs and risks for financial institutions.
- Interacting with value chains (agricultural production or machinery value chains) is a helpful way to manage risks and transaction costs for financial institutions.
- After daunting experiences with subsidies for agricultural finance in the past, any subsidies for promoting mechanisation finance should be “smart”, that is, conform with market dynamics to suit the market-oriented paradigm.

This study shows that mechanisation in SSA has the potential to contribute significantly to the food security of the region's rural populations. Yet, as some of its social and ecological effects may be ambiguous, mechanisation will always involve the need for an adequate and thorough analysis of the

contextual conditions that need to be in place to reduce the risk of adverse effects and ensure sustainability.

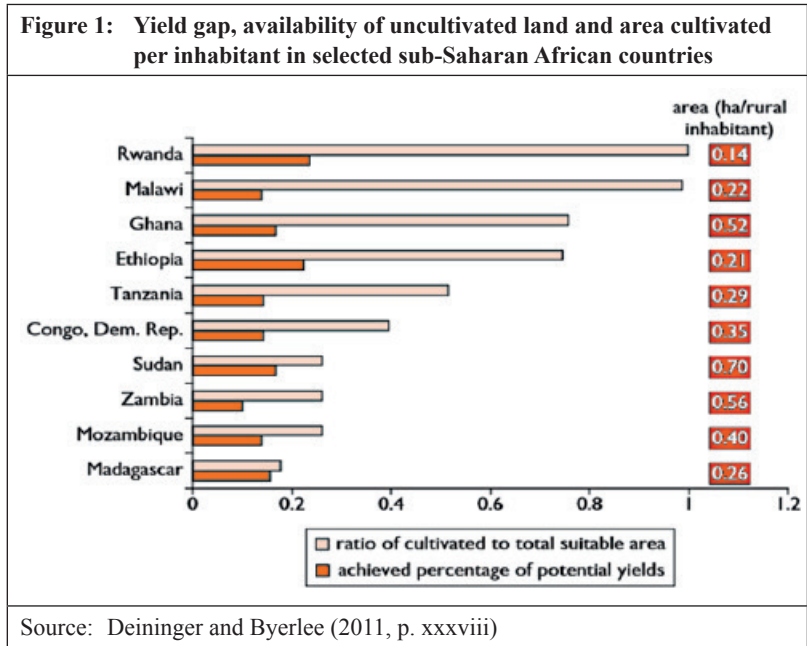
By enabling smaller farmers in particular to access financial services – including investment loans, leasing, insurance and payment services – mechanisation can be scaled-up. Financial products should facilitate different ownership and usage models for mechanisation, including co-ownership or hiring contracts. A high degree of adaptation of financial products to the medium-term nature of machinery finance and agricultural income patterns is required to ensure that any investment in machinery use is commercially viable and can ultimately contribute to food security in the region.

1 Introduction: the food security challenge and the promise of financing mechanisation

At present, SSA is home to about 220 million undernourished people. A total 23.2 per cent of the population is food insecure, making SSA the region with the highest prevalence of food insecurity in the world, and one of the few world regions where the number of undernourished people is increasing in absolute terms (Food and Agriculture Organization of the United Nations [FAO], 2015; FAO, International Fund for Agricultural Development [IFAD], & World Food Programme [WFP], 2015; von Grebmer, Bernstein, Prasai, Yin, & Yisehac, 2015). Extremely rapid and unprecedented population growth in SSA will further aggravate the situation. This will be a major challenge for many countries, such as, for example, Nigeria, where the population is projected to more than double within the next 35 years – from 174 million to 440 million people (Population Reference Bureau [PRB], 2013).

Tackling the current hunger crisis will require us to think in different directions. Food insecurity and hunger have many different roots, and, more importantly, many possible ways to a solution. From a conceptual point of view, we will have to understand food insecurity in SSA as a multidimensional issue of supply or availability of food, and of individual physical and economic access, with questions of global food distribution and discriminating market mechanisms being part of the problem (Collins & Chandrasekaran, 2012; Royal Society, 2009). Yet, the availability and access components of food security will have to be secured through increased agricultural production and reduced food loss in those regions most affected by food insecurity. This puts SSA's agricultural sector centre stage in the fight for food security – especially when considering the irony that the region's smallholder farmers are not only important producers of food goods, but at the same time also those most vulnerable to food insecurity (FAO et al., 2015): many of the households from RW 3 and RW 4 are currently net food consumers. Agriculture is key in (1) increasing global, national and local food availability, (2) providing income sources for food purchase, and (3) improving people's nutritional status through production of adequate and diverse food (World Bank, 2007). With most rural people in SSA being involved in agricultural activities to some extent, improvements in this sector can have a major impact: "In SSA specifically, investment in agriculture contributes 4.25 times more towards reducing poverty than comparable investments in any other sector" (von Braun, 2013, p. 154). Not

only is SSA’s agriculture sector in need of improving its production – it also has a huge potential to do so, as can be seen in Figure 1. SSA has huge land reserves suitable for agricultural use; land productivity rates, that is, yields per unit of area, are the world’s lowest, with an estimated yield gap³ of up to 80 per cent (Deininger & Byerlee, 2011; FAOc, 2011).



Although there are many ways to increase the availability of food, mechanisation is frequently mentioned as a particularly important one, as it can respond to various challenges in the region. In this study, we embrace an understanding of mechanisation that is broad in intensity as well as scope: it includes *low-intensity* (manually powered tools), *medium-intensity* (draught animals and smaller machinery) and *high-intensity* (bigger machinery)

3 Yield gaps are a measure to compare “current productivity with what is potentially achievable assuming that inputs and management are optimized in relation to local soil and water conditions” (FAOc, 2011, p. 35). The methods of establishing counterfactual scenarios for comparison vary greatly and are subject to heavy discussion (Beddow, Hurley, Pardey, & Alston, 2015). Yet, these numbers can serve as an approximation to highlight the great potential that lies in increasing agricultural productivity in SSA.

mechanisation. Although our focus is on mechanisation in the field, we also look at all other on-farm value chain tasks, including first processing and storage steps as well as transport.⁴

Demographic changes in the past decades have seen an “exodus of entrepreneurial and innovative young people” (Mrema, 2011, p. 24) into urban areas, where they hope for better paid and less arduous employment opportunities. Urbanisation rates in SSA are the world’s highest: 4.2 per cent in 2013 (World Bank, 2015d; Hanson, 2007). Migration from rural areas, especially of better-educated youth, is putting pressure on the agricultural sector by lowering the ratio of food producers to consumers. The HIV/AIDS pandemic has further contributed towards the shrinking of the agricultural labour force and rising agricultural wages, resulting in severe farm power shortages in many regions, where the majority of households are not able to cultivate all of the land at their disposition (Clarke & Bishop, 2002; Kienzle & Sims, mimeo; Shetto, 2011). This stresses the need for mechanisation-facilitated increases in the productivity of labour for critical farm tasks to overcome specific labour bottlenecks. Where mechanised equipment reduces the arduousness of farm work, agriculture may represent a more attractive employment option for the young and more educated, thus slowing down rural-urban migration. “The low level of mechanization in the region is one of the most serious obstacles to expanded and sustainable utilization of the ample land and water resources for agriculture” (Hatibu, 2013, p. 2).

Thus, the biggest promise of mechanisation is its contribution to almost immediate increases in the productivity of labour, that is, output per agricultural worker. Agriculture in SSA is mostly characterised by small-scale and subsistence farming, continuing a centuries-old tradition of hand hoe cultivation. In the mid-2000s, 65 per cent of farmland in the region was primarily being cultivated manually, severely restricting the amount of land a family is able to cultivate due to labour bottlenecks in time-bound, yet labour-intensive, farm tasks (FAO, 2008). The mechanisation of critical steps in the growing cycle can help to eliminate these labour bottlenecks, allowing households to increase their area of production. Mechanisation can also contribute towards enhancing the productivity of land, for example by allowing field preparations to be carried out in a timelier manner or by

4 This excludes mechanisation of tasks not directly linked to agriculture, most importantly non-agricultural transport, electricity and the mechanisation of food preparation, such as stoves.

enabling access to – and transport of – farm inputs such as fertiliser, which in turn contributes to higher yields. Raising the productivity of labour and land in the region’s many small and medium-sized farms will thus be crucial to increase local food production and enhance both the availability of and access to food for SSA’s rural poor and the growing urban populations (Hazell, Poulton, Wiggins, & Dorward, 2007). By replacing manual with animal- or machine-driven power sources, mechanisation has the potential to facilitate this much-needed boost in agricultural productivity in an ever more challenging context.

Furthermore, high post-harvest food loss poses a major additional problem in SSA: “Significant volumes of grain in developing countries are lost after harvest, aggravating hunger and resulting in expensive inputs – such as fertiliser, irrigation water, and human labour – being wasted” (World Bank, 2011a, p. xii). Here, too, mechanisation can potentially offer major improvements by replacing improper harvesting and processing methods and upgrading inadequate storage and transport facilities (World Bank, 2011a).

Why is now a good time to revisit mechanisation in SSA?

Mechanisation has long been neglected due to the failed agricultural policies and projects of the past decades. During the 1960s and 1970s, mechanisation efforts in SSA of governments and development cooperation focussed primarily on the import of large tractors, made available in state-run hiring schemes. Despite huge efforts and large sums of financial aid, the approach proved unsustainable: spare parts, technicians and fuel were lacking, contributing to long downtimes of machinery. Furthermore, large tractors were not in demand, as many area-specific cultivation patterns neither needed nor allowed the use of machinery, or were so small that tractors were not appropriate mechanisation options. Long distances between small farms made state hire schemes unprofitable, with corruption and elite capture aggravating the situation (FAO, 2008; Van Loon, Baudron, & Krupnik, 2015). Although some of these and other barriers are still in place (see Section 3.2), other external factors have changed over time, opening up new opportunities and aggravating the need for mechanisation in the region.

New opportunities for mechanisation arise out of important changes in machinery supply and food demand. Previous mechanisation efforts in SSA

have seen a concentration on the import of machinery from industrialised countries that were adapted to capital-intensive farming, being large, expensive and complicated to handle. Today, machinery supply in SSA is much more diverse. Smaller and cheaper equipment adapted to small-scale agriculture is entering the markets from emerging economies such as India and Brazil, creating new options for low- and medium-intensity mechanisation (FAO, 2008; Kienzle & Sims, mimeo). Changes in food demand, on the other hand, arise mainly out of unprecedented population growth and high urbanisation rates. Pressure on regional and domestic food markets is tightening, and the growing middle class will raise the demand for processed and high-quality food goods in the urban centres. World markets reveal higher food prices than before the food price crisis in 2007/2008, and climate change, natural resource depletion and low investment levels in agricultural research could slow down food production increases in many parts of the world and foster relative food scarcity. These trends open up new opportunities for the marketing of higher quantities and more diversified food crops in SSA, thus incentivising farmers to produce more (Baudron et al., 2015; FAO, 2015; Garrity, Dixon, & Boffa, 2012).

Additionally, new needs for mechanisation may arise to facilitate adaptation to changed circumstances. In more densely populated regions, for example, continuing population growth has led to sudden land scarcity, resulting in fragmentation of the cultural landscape and shrinking farm sizes (Garrity et al., 2012). Moreover, the reoccurrence of extreme weather events and shortening or erratic rainfall periods associated with climate change have aggravated the need for timely and fast field operations to avoid yield penalties and enhance resilience. Climate variability also calls for adapting agricultural practices that may require additional farm power for new labour-intensive yet sustainable methods of production, such as Conservation Agriculture (CA)⁵ (Alliance for a Green Revolution in Africa [AGRA], 2014; Kienzle & Sims, mimeo).

Combined, these developments result in the need and opportunity for farmers in SSA not only to produce more, but also to produce differently

5 CA is a paradigm and set of practices in sustainable agricultural development. It is grounded on three main principles: minimal soil disturbance, permanent soil cover and crop rotation / diversification. The concept is being promoted by different agencies such as the Food and Agriculture Organization of the United Nations (FAO) and the Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center – CIMMYT) (Anderson & D'Souza, 2014).

(Baudron et al., 2015). Mechanising farming is one of the key priorities of the African Union's "Agenda 2063: The Africa We Want", where it is suggested in the first of its seven aspirations that "the hand hoe will be banished by 2025" (African Union, 2014). This will require a shift in farm power, and mechanisation has the potential to fill this gap (Clarke & Bishop, 2002).

Yet, mechanisation has a bad reputation in SSA, mainly originating in the failures of past state and donor-led mechanisation efforts. Most of these mechanisation programmes proved unsuccessful, and quite a few brought along a host of negative results – ecologic effects, such as soil depletion and deforestation, and socio-economic effects, such as rural unemployment, land concentration and displacement, and a strengthening of dependency structures. This has led to a neglect of farm power,⁶ which currently can be considered the "forgotten resource" (Baudron et al., 2015, p. 892) in agricultural development. In the light of recent socio-demographic, climatic, technological and agricultural developments, however, mechanisation deserves reconsideration as one of the most important steps on the path to food security in SSA. Yet, the failures of the past have shown that the connection between mechanisation and food security is not a straightforward one. Potentially negative effects will thus have to be analysed to avoid repeating past mistakes.

Being dependent on a variety of factors, mechanisation is not an easy endeavour. Living realities in SSA are complex and diversified, and past experience has brought to light the many obstacles that stand in the way of its successful introduction. One of the most important constraints for mechanisation in SSA today is access to finance. Being a major investment for any farmer, mechanisation places farmers in a position of needing financial services. However, access to finance in general remains a challenge in rural areas of SSA – and even more so in the agricultural sector. Estimates by FinScope⁷ suggest that 30–60 per cent of the rural populations in SSA have no access to financial services at all (FinScope, 2014). So far, the little finance provided to the agricultural sector is mainly for farming inputs such

6 The term "farm power" summarises the power sources available on a particular farm for employing the relevant farming tasks. It comprises human, animal and machine power.

7 FinScope surveys are nationally representative surveys of consumers or small business owners to investigate the way they source their income and manage their financial lives. FinScope surveys look at the use of – and demand for – financial services, including informal products. See <http://www.finmark.org.za> for more information.

as seeds and fertiliser. Yet, providing financing for mechanisation carries additional challenges: although inputs can usually be covered with small loan amounts with short maturities of a maximum of one year, purchasing machinery or animals requires larger loan amounts with tenures between one to five years. In addition, although inputs are often crop-specific and are provided and guaranteed within value chain arrangements, many types of mechanisation (particularly the larger ones such as animals and tractors) have a whole-farm nature, that is, they are only financially viable if used in more than one specific value chain. Financing mechanisation is thus more challenging and requires specific tools, capacities and a skilled combination of agricultural and financial knowledge. Additionally, financing mechanisation brings together the most difficult challenges associated with agricultural finance: high loan sizes, long tenures, need of high value securitisation and, finally, a good understanding of the operational and financial changes that mechanisation brings to an agro-enterprise.

Our study: research questions and approach

Decision-makers in development cooperation face numerous challenges when working on enhancing food security, because causal relations between different intervention instruments are complex and often difficult to assess. Whereas interventions in the agricultural sector may have a more direct effect on food security, interventions geared towards the agricultural sector through the financial sector can only aim to strengthen the agricultural sector as such, and hence have indirect effects on food security. This study focusses on a particular financing purpose – agricultural mechanisation. It considers non-financial aspects of mechanisation and analyses to what extent mechanisation can affect food security. Then the focus is put on one of the core barriers to mechanisation in SSA, which is access to finance to fund new machines and equipment. We analyse which aspects on the supply side of financial services as well as on the demand side constrain access to finance and which solutions may facilitate better mechanisation finance. The following two questions guide the analysis:

What are the effects of agricultural mechanisation in SSA – and how do they influence food security?

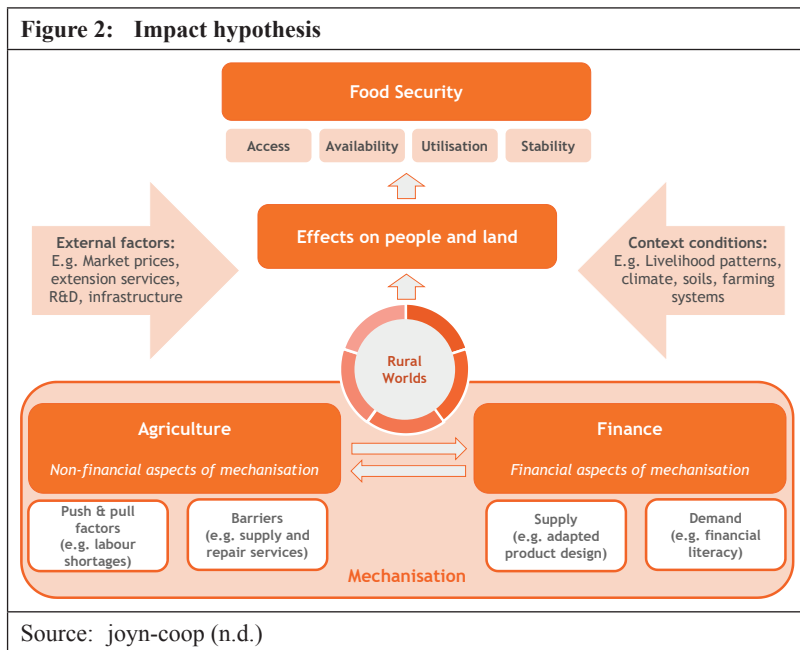
What are the financial aspects of mechanisation? How can access to finance for mechanisation be achieved?

If past mistakes in mechanisation efforts are to be avoided, knowledge exchange and cooperation between the agricultural and financial sectors will be crucial for the success of future policies and projects. The present study aims at facilitating this kind of knowledge exchange by offering a comprehensive analysis of the above questions and important contextual issues that is relevant to experts and practitioners in both fields. We aim at explaining our findings in a way that is “understandable” for both the finance and agricultural sectors. This implies that some explanations might seem obvious for readers in their own respective fields.

Our study combines and triangulates a multitude of data sources and expert opinions. We conducted a comprehensive literature review, thoroughly analysing relevant literature documents and case studies. In addition, we held more than 40 semi-structured interviews with agricultural and financial development experts. Researchers, practitioners and professionals from all over the world have provided valuable insights into their fields of expertise, inter alia from the FAO, the International Fund for Agricultural Development (IFAD), national development cooperation bodies and from financial institutions based in SSA (see Annex I for a complete list of interview partners).

Figure 2 highlights the different topics that we cover in this study, and how they are interconnected.

In order to understand the particular challenges and constraints that affect both the non-financial and financial aspects of agricultural mechanisation, we shed light on the complex and diverse living realities of rural people in SSA – the five “RWs” – and point out their particular exposures to risks. No less diverse than the rural stakeholders are their respective options for mechanisation. We therefore provide some technical insight into what mechanisation entails and highlight current barriers to successful mechanisation in SSA. A thorough analysis of the intended and unintended consequences that mechanisation can involve in SSA – both in agro-ecological and in socio-economic terms – and their potential effects on food security allow us to present some crucial success factors for future efforts of sustainable mechanisation in SSA.



One of the core barriers to mechanisation is access to finance, and we show the particular constraints and requirements that mechanisation poses, both on the supply and demand sides of financial services. Here, too, we offer advice on what successful finance for mechanisation might look like.

The study's approach of offering a generally comprehensible overview necessarily sets certain limits. It did not allow us to do sufficient justice to SSA's great climatic, demographic, cultural, socio-economic and agro-ecological diversity. However, we point to this diversity and indicate where more detailed specification is needed. Moreover, the identification of concrete cause-and-effect relationships between an individual financing instrument, a mechanisation tool and a specific outcome regarding food security is beyond the scope of this research. If at all possible, answering these questions in detail would require in-depth and long-term empirical impact studies of individual cases. But rough orientations about principles and directions are provided. Finally, notwithstanding their importance for poverty reduction and food security in rural SSA, other and more direct effects of financial services on food security beyond financing mechanisation

– for example, allowing consumption smoothing through loans, savings and money transfers – are not covered in this study.

We proceed in three steps. Chapter 2 outlines some of the most important contextual factors for mechanisation in SSA, presenting the five RWs as an analytical framework and evincing rural households' livelihood strategies in a fundamentally risky environment. In Chapter 3, we look at the non-financial aspects of mechanisation, presenting the barriers as well as the potential social and ecological effects and their implications for food security before distilling the success factors of mechanisation in the region. In Chapter 4 we then focus on the financial aspect of mechanisation. We offer a comprehensive picture of both the demand and supply sides of financial services, and the respective difficulties they face in SSA. Chapter 4 recapitulates on the findings, provides an outlook and suggests areas for further research.

2 The context for mechanisation and agricultural finance: complex rural livelihoods in SSA

Rural populations in SSA differ vastly in various respects. However, many face similar challenging conditions and have found ways of living and working to handle them. This has important implications for the adoption of mechanisation and access to finance, offering both challenges and opportunities. In this chapter, we therefore shed light on rural livelihoods in SSA. The concept of the five RWs are introduced as a conceptual framework to grasp the diversity of rural people and allow for the identification of interconnections and indirect effects with regard to mechanisation. Farming households face large and fundamental risks, and there is hardly insurance to protect against them, which is why farmers tend to follow strategies of risk avoidance and risk diversification in decision- and investment-making. Decisions are also influenced by people's embeddedness into solidarity-oriented family and social systems, which work as informal insurance, and by rural households' agricultural and business practices, which follow a logic of family-led economies rather than one of capital accumulation. Finally, the gender division of agricultural labour in many areas of SSA highlights the importance of putting a special focus on women in mechanisation.

Rural populations are diverse, but interlinked: the OECD's five Rural Worlds

With 63 per cent of SSA's populations living in rural areas in 2014 (World Bank, 2015a), these populations are necessarily extremely diverse. In order to account for this diversity in agricultural policy-making, the OECD suggests classifying rural populations in SSA into the so-called five RWs:

By using a more differentiated analysis based on people's livelihoods, [the typology of Rural Worlds] makes clear that poverty is located unevenly across and within rural populations, that policy in and for agriculture affects different groups in different ways and that the actions of one rural group can improve or impair the livelihoods of others. (Organisation for Economic Co-operation and Development [OECD], 2006, p. 11)

The five RWs⁸ serve as a conceptual framework for our study to point out both the variety of rural populations' financial needs and opportunities, and the diverse effects that mechanisation can have on their livelihoods. Having a clear picture of this diversity in mind is crucial for understanding that there is no one-size-fits-all solution to mechanisation and agricultural finance in SSA.

The OECD's segmentation is based on different levels of income and assets, food production and consumption, market integration, and access to financial services and infrastructure, inter alia. Households within and between the different RWs are interlinked in economic and social terms, and shifting from one RW to another due to income improvements or adverse events is not uncommon.

8 SSA's rural population is extremely diverse in many respects, making it almost impossible to build analytical categories that capture all groups and people in a comprehensive way. The OECD categorisation of the five RWs focusses mainly on those rural groups more or less directly involved in agricultural activities. Non-agricultural rural households, such as shopkeepers and mineworkers, are almost excluded from the picture unless they, too, are engaged in agricultural activities of some kind. With our study's focus lying on agricultural mechanisation, we embrace the OECD's classification for analytical purposes and with respect to comparability of future studies in the same field within DIE's SEWOH project while acknowledging this incompleteness.

Rural World 1: Large-scale commercial agricultural households and enterprises



Large
commercial
enterprises

Stakeholders in this world are a minority in SSA. They grow and process crops for sale in national, regional and international markets, and are both economically and politically powerful players. Access to inputs and financial services is easily available to this group, as is access to sufficient and nutritious food. Their farms and companies can be important sources of employment (inter alia depending on crops and the level of mechanisation), both for agricultural labourers and contract farmers in RWs 2, 3 and 4 (OECD, 2006). As this group is rarely the target of development cooperation interventions, and because it does not face major difficulties in accessing mechanisation, our study only considers RW 1 when evaluating the effects of its mechanisation on other rural groups.

Rural World 2: Traditional landholders and enterprises



Traditional
SMEs

These farmers and entrepreneurs form a significant share of the rural households in developing countries, and some are part of the local land elites, possessing relatively large landholdings. They constitute a large segment of the group of “emergent farmers”⁹ and are engaged in both subsistence and commercial production. Yet, they are said not to be internationally competitive because of their local embeddedness, product quality, production and aggregation costs, and their lack of ties to important agribusiness supply chains. Stakeholders in this group face many difficulties in reaching out to formal financial and risk-management services (OECD, 2006). Recent research has revealed that off-farm employment opportunities are an important feature of this group, used to extend income streams in times of little agricultural activity or to fund farm purchases (FAO, 1992; United Nations Conference on Trade and Development [UNCTAD], 2015).

9 “Emergent farmer” or “emerging farmer” is a term that has been coined to differentiate a particular subgroup of smallholders who are – or have been – moving from small-scale subsistence to medium-scale commercial production. Despite the lack of a clear definition as to what the notion entails, it is used by different institutions and companies, also in the context of financing mechanisation (see e.g. NWK Agri-Services, mimeo).

Rural World 3: Subsistence¹⁰ agricultural households and micro-enterprises

Rural households in this group form the wide array of smallholders, pastoralists and fishermen – a diverse group of people who are primarily producing for home consumption, but employ a host of different livelihood strategies, including market activities, off-farm labour and migration (OECD, 2006; World Bank, 2007). They have very limited assets and are very frequently employed in off-farm work to make a living, including to buy food. Thus, they are often dependent on employment opportunities in RWs 1 and 2, for example as contract farmers for traditional export crops or farm labourers. Their social sphere is mainly confined to their local community, limiting their financial and risk-management opportunities to the informal sector (OECD, 2006).



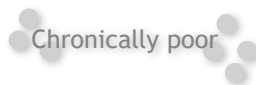
Rural World 4: Landless rural households and micro-enterprises

This group does not own agricultural land and is largely dependent on sharecropping, hiring out labour to other farms, or working off-farm in urban centres or infrastructure investments. They, too, need RWs 1 and 2 (and 3) for employment and income-earning opportunities; yet, their low education levels often hinder them from graduating out of poverty (OECD, 2006). It should be noted that in SSA, landlessness is far less frequent than in other world regions.



Rural World 5: Chronically poor rural households

People in this population group are often not (no longer) economically active and have lost or sold almost all of their assets. HIV/AIDS, droughts, floods, old age or other factors have

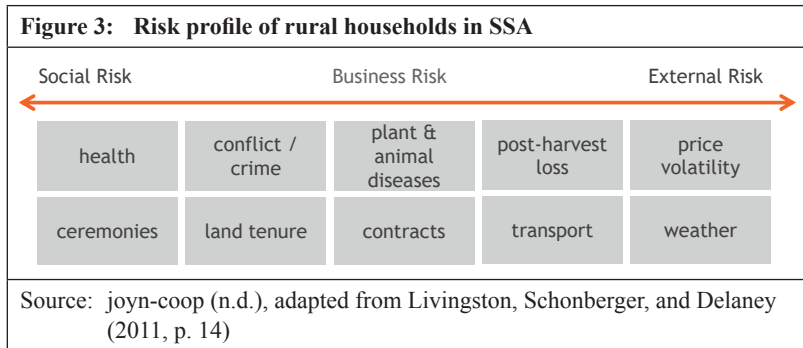


10 The term “subsistence” usually refers to production systems with little or no surplus production for sale. Yet, in SSA today, most smallholder farming households find themselves on a continuum between pure subsistence and pure commercial production, with different degrees of market integration (Miracle, 1968): “Pure subsistence production is now virtually non-existent in Africa” (International Livestock Research Institute [ILRI], 1995, p. 35).

driven many, including widows and orphans, into chronic poverty. They rely on relatives and government-provided safety nets for survival (OECD, 2006). We only indirectly focus on this group in our study, as they can be “reached through social assistance programmes and therefore are largely outside the immediate reach and attention of agriculture-enabled economic growth policy” (OECD, 2006, p. 62).

Rural people live and work in mixed livelihood systems to manage risks

Farming is a risky business. This is particularly true for poor households, where farming risks are compounded with household risks, and where the occurrence of certain risks might have dire consequences. Therefore, livelihood strategies adopted by farmers always have to be understood in terms of risk. Since investing in mechanisation involves major financial and economic risks, it is crucial to picture rural households’ risk patterns in order to understand the particular (dis)incentives for engaging in mechanisation. The risks faced by agricultural households include social, business and external risks (see Figure 3).



Social risks encompass unexpected health expenses as well as costs for family ceremonies, such as funerals or weddings. Conflict and crime as well as land tenure insecurity are significant challenges in some SSA countries. Business risks include plant and animal diseases as well as contract issues, post-harvest losses and transport risks. Lastly, price volatility and bad weather are important external risks.

With varying involvement in agriculture and income levels, risk patterns and exposure may differ between the five RWs. Some risks are common to all rural people, including health risks, natural disasters and large-

scale conflicts (OECD, 2006). Those households engaging directly in agriculture, as business entrepreneurs and producers face the highest risks, such as plant and animal diseases, weather effects and, to some extent, similar commercial risks, such as volatile prices (Ndiame, 2015). However, vulnerability to these shocks differs between households. Subsistence producers in RW 3 with the least access to irrigation may be harshly affected by a drought, whereas RW 1 may even benefit if prices go up and some producers in RWs 2 and 3 join the agricultural labour force, driving down wages (OECD, 2006). Commercial risks are especially high for smallholders in dispersed supply chains. In integrated markets, risk-sharing among supply-chain actors is generally better (Livingston et al., 2011).

The fact that most farms are managed as family-led businesses requires risk-management strategies that take into account both the household and the farm:

[T]he inter-linkage between productive and domestic risks means that strategies to address risk and associated vulnerability for rural households must incorporate a portfolio of risk management instruments, addressing risk in both productive and domestic arenas. (OECD, 2006, p. 64)

These risk-management strategies can be divided into three types, all of which may be relevant for mechanisation and its financing: *prevention* strategies reduce the probability of an adverse shock occurring and include, for instance, investment in irrigation infrastructure, which reduces the risk from droughts; *mitigation* strategies are implemented before a shock and reduce the impact once it occurs, for example through the diversification of livelihood strategies or insurance instruments; *coping* strategies include financial services, reciprocity-based schemes and social welfare programmes to deal ex post with shocks (OECD, 2006).

Stakeholders in RWs 2, 3 and 4 are often poor and exposed to a whole variety of risks – above all, seasonal risks and unsteady income flows associated with rainfed agriculture. In order to reduce vulnerability and generate income, they pursue distinct strategies of livelihood and crop diversification. Mixed livelihoods are thus one of the central characteristics of the economic patterns of farm households of RWs 2 and 3 (Banerjee & Duflo, 2006).

In the absence of social security systems and formal risk-mitigation options, poor people – and particularly poor farmers – tend to follow risk-averse behavioural patterns, translating into low-risk / low-return farming

strategies (Brüntrup, 1997; Livingston et al., 2011; World Bank, 2007). Farmers try to reduce agricultural risks through on-farm diversification patterns, such as mixed or multi-storey farming systems with high outputs but excessive labour demand (IFAD, 2010), by using traditional low-cost – and hence often low-yielding – seed varieties and technologies, and/or by farming extensively and planting more than they can take care of.¹¹ These strategies may waste inputs, time and labour through lower yields and lost earnings in some years, but they keep options open in others, protecting family-led farms from catastrophic losses (Delve & Twomlow, 10/2015; Dercon & Christiaensen, 2011). This behaviour is thus rational for the individual farmer under risk considerations – but it also limits her potential: “Subsistence production for home consumption is chosen by farmers because it is subjectively the best option, given all constraints. In a global sense, however, it is one of the largest enduring misallocations of human and natural resources” (von Braun, 1994, pp. 3–4).

In addition to on-farm risk-management strategies, virtually all households in RWs 3 and 4, and many in RW 2, also employ strategies of income diversification in order to reduce the risks to own agricultural production. Apart from on-farm work on the plots of bigger farmers, employment can be found in other rural agricultural enterprises (e.g. in value addition), in non-agricultural rural micro-enterprises, and in the urban centres (Christen & Anderson, 2013; OECD, 2006). Diversification into farm and non-farm employment can thus be seen as a general trend in SSA, with agriculture remaining a distinct part of most rural households’ income patterns: “Although for many small farms the importance of farming in household income has declined, the number of rural households who use farming as a platform for their livelihood strategies continues to grow” (Hazell et al., 2007, p. 2).

These risk-mitigation strategies entail various implications for mechanisation, which are discussed in Section 3.2. When considering agricultural finance, too, it is important to keep in mind that diversification and strong seasonality are key determinants of rural livelihoods in SSA. In most rural families, agricultural and household financial needs are interwoven, and most agricultural needs are fulfilled using a variety of financial tools and income sources. Yet, in some instances, demand-oriented financial products may be needed to serve more specific agricultural needs and bigger farm

11 For evidence from Pakistan, see Kurosaki and Fafchamps (2001).

investments (Christen & Anderson, 2013). Financial services can support farmers with efficient risk-management tools for large covariant risks (e.g. extreme weather) and provide them with access to working and investment capital for their preferred production choice. However, some financing options can themselves be seen as an additional risk, with additional costs that expose farmers to the risk of not being able to repay the loan (Adams & von Pischke, 1992).

Family-led economies and solidary family systems inhibit investment in mechanisation

The economic logic of mixed livelihood systems is family-driven and closely embedded into the respective social context. Family-led farms or businesses are run with the labour force and assets of the family (Nitsch, 1995, p. 93). From a micro perspective, family-led economies are characterised by their vital links to surrounding social networks – generally reciprocity-based relationships with family members and relatives – along with market-based relationships. Accordingly, the way in which economic decisions are made depends strongly on the respective social and cultural contexts. Thus, responding to cultural norms of reciprocity, economic decisions are made based on a mix of economic and social motives (Zattler, 1997). Family-led economies should therefore always be seen as the interplay of the family business, the household and the surrounding social context. For family-led farms, the central variable to maximise the families' utility is the return on their labour.¹² According to Čajanov (1923), the factual budget restriction for the family economy is labour, that is, how much family members are able and willing to work. In situations of insufficient income-generating alternatives, missing opportunities to increase labour productivity (e.g. through mechanisation) can lead to drudgery, as more labour is needed to produce the necessary consumption needs (e.g. food crops). Likewise, a lack of farm power or appropriate equipment can drive labour-constrained, poor households with various income opportunities out of agriculture.

12 Based on his investigations of family-led agriculture in rural Russia, Čajanov (1923) shows that a distinct calculation of acceptable business results has to be considered for family-led economies. The relevant category is the net labour output, which is calculated by “gross earnings – expenditures = net labour return”.

When discussing options for agricultural development and mechanisation in SSA, we need to take into account the existence of family-based duties of wealth redistribution (Rauch, Beckmann, Neubert, & Rettberg, forthcoming). If (re)distribution occurs on a *horizontal level* – meaning that goods or gifts of the same value are mutually exchanged within a certain period of time – it is referred to as “reciprocity”. A typical example of reciprocity is mutual support, for example among neighbours (or also family members) in case of need. Reciprocity is very common among peasant societies, especially under conditions of subsistence and scarcity, and the obligation of mutual help functions as an effective risk-management tool – as a “mutual insurance” (Fafchamps, 1992, p. 148). It may have its limitations, however, in events of covariant shocks, that is, if all groups are struck by a calamity and have nothing to share. In this case, diversification in crops and income sources will sustain the capacity for reciprocity.

If the exchange of goods occurs on a *vertical level* within a family (or on a community / societal level) – that is, the provision of goods or gifts without the obligation of the receiver having to give something back – this is referred to as “redistribution” (Hirschberg & Müller, 1999). A typical example is the social obligation of a person who runs a successful business to provide employment, gifts or money to her¹³ family members: the wealth that one individual of a family accumulates must be shared with her relatives, especially if one family member is in need of support. This duty is guided by the idea of solidarity, meaning that the interest and wellbeing of all group members stand above individual interests. These systems risk breaking if individual members decide to refuse to share their wealth.

In many societies in SSA, family-based obligations to share wealth exist in different forms. They are found to prevail in regions or countries where the public social safety net is weak or absent (Alby, Auriol, & Nguimkeu, 2013; Beekman, Gatto, & Nillesen, 2015) – that is, almost everywhere in rural areas. Alby et al. (2013) refer to redistribution as what they call “family tax”, which successful businesspersons are expected to pay to their relatives. They even go as far as to describe the social pressure to share wealth as a core barrier to entrepreneurship in many African societies: “People may seek to hide, dissimulate, or misrepresent their situation of

13 When we use the expression “her” for purpose of better readability, both males and females are included.

need or affordability. They also may be tempted to work less and rely on the mutual insurance system for their subsistence” (Fafchamps, 1992, p. 149).

During the research for our study, many experts underlined the importance of redistribution, pointing to its effect that people may avoid investments that bring a higher visible and taxable income. The additionally earned income will have to be distributed again in any case, and will not be of personal benefit; additionally, pressure rises to feed more family members in the following seasons, too. This affects not only the motivation of a farmer to invest in machines, but also her ability to do so, since it might be difficult for the particular farmer to reserve the gained income to pay back the loan (Neubert, 10/2015; Ratnayake 11/2015). Savings and mobile phone products can play an important role here, as they provide private and confidential access, allowing people to “hide” their wealth from their families. As a general disincentive to invest, redistribution practices may also influence decisions about mechanisation and other investments, setting barriers to poorer people for migrating out of poverty, for example into RWs 2 or 1. On the other side, employment opportunities in RWs 1 or 2 may be part of intra-family redistribution patterns, thus inhibiting a selection of the workforce based on economic criteria, but also creating flexibility for reorganisation (Brüntrup, 1997). Another consequence of embedding mechanisation in the social context is that equipment and tools are shared with others – a potentially important spillover effect.

Case Study “myAgro”

The organisation myAgro has provided an approach for confidential and hidden saving by offering farmers to use scratch cards available at the local village store to top-up a personal mobile savings account reserved for agricultural inputs and tools. See Case Study 1 in Annex 2 for a detailed description.

Gender gap in agriculture

In SSA and elsewhere, women engaged in agriculture face severe societal and institutional constraints in accessing crucial inputs, services and assets. This not only negatively affects the women themselves, but also society as a whole by setting limits to overall productivity growth (FAO, 2011; Höllinger & Staatz, 2015). In agriculture, granting women the same access opportunities as men “could raise total agricultural output in developing

countries by 2.5–4 per cent, which could in turn reduce the number of hungry people in the world by 12–17 per cent” (FAO, 2011b, p. 6). Based on household surveys in Burkina Faso, Alderman, Hoddinott, Haddad, and Udry (1995) estimate that a reallocation of manure and labour from male to female plots could allow for a household’s total increase in output of 10 per cent. Where fixed assets are needed as collateral for loans to finance inputs, working capital and investments, women are especially constrained by discriminating ownership structures (FAO, 2011b). The possibilities and constraints of women in these respects are also shaped by the household’s position within the five RWs.

Women comprise a large share of agricultural work in SSA, accounting for more than 50 per cent of the agricultural labour force (FAO, 2011b) – albeit with huge regional differences in the female share of labour: from 24 per cent in Niger to 56 per cent in Uganda, according to recent estimates (Palacio-Lopez, Christiaensen, & Kilic, 2015). However, women’s work in agriculture goes “mostly unpaid and unrecognized” (Grassi, Landberg, & Huyer, 2015, p. 1). Additionally, women are facing a triple work burden in the reproductive, productive and social domains, with social status playing an important role in determining the opportunities and capacities of women (Doss, 1999; Grassi et al., 2015). Many agricultural communities in SSA see a more or less strict (though gradually changing) gender division of labour in crop production. This division can occur with regard to crops, with women being traditionally responsible for subsistence crops and men for cash crops. Alternatively – or sometimes simultaneously – gender division may also occur with regard to farm task, with women’s tasks often being extremely time-consuming and cumbersome, resulting in “time poverty” (Grassi et al., 2015, p. 11) for many. Women are usually responsible for household tasks such as fetching water and firewood, care work and cooking, and for subsistence production. In turn, men typically do land preparation and construction work and are more engaged in cash crop production and off-farm employment. Labour division for other tasks is more variable, but often women are responsible for the weeding, harvesting, processing and transport of the harvest from field to farm, whereas taking care of animals or machines and pursuing market interactions falls into the male domain (Doss, 1999; Grassi et al., 2015; Lele, 1975; Tersiguel, 1995). These patterns of gender division of labour can hardly be generalised for all sub-Saharan African countries or communities, and some regions do not see

any gender division at all (Palacio-Lopez et al., 2015). Yet, when it comes to the mechanisation of agricultural tasks, “[m]en are often ‘gatekeepers’ to women’s access to technology” (Grassi et al., 2015, p. 31).

Accordingly, mechanisation rates for women are even lower than average. In some areas, yield differences between plots controlled by male and those controlled¹⁴ by female farmers reach up to 30 per cent (FAO, 2011b). This indicates “substantial inefficiencies” (Alderman et al., 1995, p. 22) in the allocation of factors of production on a household level. The high gender yield gaps in parts of SSA are largely explained by women’s significantly lower input use on their plots and higher access constraints:

Social conventions in many countries restrict women’s access to factors of production and services such as improved land and credit that are critical to productivity growth. Extension services often are predominantly staffed by men, and extension messages may not be oriented to women’s concerns. (Höllinger & Staatz, 2015, p. 16)

Yet, due to waves of (seasonal) out-migration of men searching for urban employment opportunities, we are currently witnessing a “feminization of agricultural labour” (Grassi et al., 2015, p. 6) in SSA. As of today, already more than 25 per cent of agricultural households in SSA are female-headed (FAO, 2011b). When speaking about mechanisation and financial access, putting special focus on reducing women’s time poverty and improving their productivity in agriculture is therefore more important than ever. This may require careful assessment of potential effects, or specific equipment adjusted to women’s needs, and, importantly, gender sensitivity in designing and implementing financial services in the context of mechanisation.

14 In some regions in SSA, the gender division of labour occurs by crop type or variety. This does not imply, however, that the respective plots are always cultivated by the female or male household members alone. Rather, women or men may mobilise male or female labour, respectively, for some of the tasks on their plots (Doss, 1999). Control over different plots is then indicative for authority over cultivation decision-making on the particular plot, or for decision-making power over the agricultural output in question (Alderman et al., 1995).

3 Mechanisation in SSA and its implications for food security

The great variety in rural livelihoods presented in Chapter 2 sets the frame for mechanisation in SSA. It necessarily affects both the range of useful mechanisation options, and the effects that these options may imply.

In this chapter, we elaborate on the non-financial aspects of mechanisation. First of all, this requires a thorough understanding of what mechanisation entails generally, and in SSA specifically (Section 3.1). The context for mechanisation in the region is very challenging, which is why we thoroughly analyse the multiple barriers to successful mechanisation in SSA (Section 3.2). Various effects that may occur out of mechanisation are discussed, highlighting differences between the RWs (Section 3.3.1). Directly or indirectly, these effects also influence food security (Section 3.3.2). From the analysis of the status quo, barriers and effects of mechanisation, some success factors for mechanisation enhancing food security are distilled (Section 3.4).

3.1 Understanding mechanisation in SSA

Although the tractor is undoubtedly the “single most important mechanical innovation in agriculture” (Hayami & Ruttan, 1970, pp. 1124–1125), mechanisation comprises more than that: it can transform the working process along all steps of the value chain and in varying intensities. Accordingly, mechanisation can be used in multiple ways and affects rural enterprises and households accordingly, depending not only on the specific mechanisation option, but also on a variety of contextual factors.

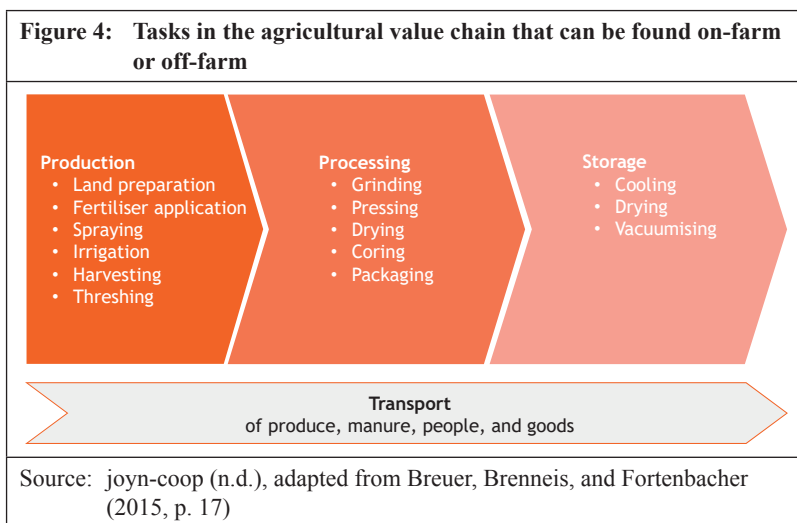
Mechanisation is more than tractorisation

In order to thoroughly evaluate both the potential benefits and risks of mechanisation, it is key to broaden our understanding of the term’s meaning. We therefore adopt a wide definition of mechanisation, both in terms of intensity and in terms of scope. According to the FAO (2008, p. 1):

Agricultural mechanization is the application of mechanical technology and increased power to agriculture [...]. This includes the use of tractors of various types as well as animal-powered and human-powered implements and tools, and internal combustion engines, electric motors, solar power and other methods of energy conversion. Mechanization also includes irrigation systems, food processing and related technologies and equipment.

In terms of scope, mechanisation frequently refers to production only – leaving aside important steps in processing, storage and transport. Yet, these steps in the value chain are critical for two major reasons: if production is being mechanised, most likely there will be an increase in output of primary agricultural goods; if downstream operational levels and markets lack capacity for handling the additional produce, larger shares of it may be wasted, thus minimising the otherwise positive effects of mechanisation on agricultural production. Hence, the whole value chain should be considered (Kaumbutho, 2011). Second, the mechanisation of processing, storage and transport can itself reduce food loss and offer new opportunities for income gains and diversification.

Our understanding of mechanisation therefore comprises not only agricultural production, but all potential on-farm steps of the value chain (see Figure 4).



Three different intensities of mechanisation can be distinguished, with matching instruments and energy sources for each level (see Table 1). The scale of our definition includes the three main farm power sources: manual technology, animal power and mechanical power (Houmy, Clarke, Kienzle, & Ashburner, 2013). It ranges from low-intensity hand tools to high-intensity, large motorised machinery. In between the two extremes, we find a broader range of medium-intensity equipment that includes draught

animals and small motorised machines. This broad approach results in a wide range of mechanisation options. Each task on every step of the value chain can potentially be mechanised in different intensities. For example, ploughing for land preparation can be done manually with a hand hoe, in medium-intensity with a plough drawn by oxen or a 2WT, or by using a high-intensity four-wheel tractor. Similarly, in processing, pressing oil can take place with a manually powered oil press, one that uses a donkey to turn the press' wheel or a small machine run by solar power, or through a large motorised machine that can process much bigger quantities.

Each piece of mechanisation equipment requires certain energy inputs as well as care (veterinary services) or maintenance (repair services). Likewise, each instrument has different advantages and disadvantages – for example, hand tools are cheap and easy to use but bring limited productivity gains, whereas draught animals bring larger gains but require long periods of training and fodder, also during the dry season.

Intensity	Energy Input	Instrument
Low	Food	(Specialised) hand tools
Medium	Fodder	Draught animals
	Fossil fuels or electricity (incl. renewables ¹⁵)	Small motorised machines
High		Big motorised machines
Source: joyn-coop (n.d.)		

There is no “mechanisation blueprint” that fits every farm in every part of SSA. To the contrary – a farmer’s decision for a certain process that is to be mechanised, or for a certain intensity of mechanisation, is determined by a host of individual as well as external factors, such as natural-resource endowment, type of land, access to water, and access to labour and capital

15 Although electricity is gaining importance in rural SSA mainly for household use (lighting, telecommunication equipment, etc.), heavy agricultural machinery has a higher power demand, requiring working current that is harder to obtain (FAO, 2000). Electric machinery can therefore only be used in areas with access to power grids. Renewable energies provide a huge potential for remote and off-grid areas to power smaller machinery such as treadle pumps or medium-intensity processing machines (for a discussion on solar energy, see Eswara & Ramakrishnarao, 2013), but their overall potential for agriculture has yet to be explored in more detail.

(Garrity et al., 2012; Kienzle & Sims, 2006). For example, on an aggregate level, decisions for (certain types of) mechanisation may be explained by the availability and cost of land and labour, as has been shown by Hayami and Ruttan's (1970) theory of induced innovation, which is driven by relative scarcities. According to them, land scarcity might incentivise farmers to invest in inputs and tools that encourage intensification – or land-saving – farming strategies, such as water pumps. On the other hand, labour-saving technologies such as tractors that encourage the expansion of cultivated land will be most profitable in scenarios of land abundance and labour scarcity, but much less so in densely populated rural areas, where land is scarcer and where labour is abundant throughout the growing season (Hayami & Ruttan, 1970; Kienzle & Sims, 2006; von Braun, 2013). Therefore, “[p]opulation density largely determines the relative costs of land and labor, which provides a framework for understanding where intensification is favorable to farmers and what strategies – labor- or land-saving – are likely to be pursued” (von Braun, 2013, p. 156). Where both land and labour pose high barriers to farm mechanisation – as is the case in hilly, steep-sloped, extremely arid or rocky regions – farm investments might not produce enough returns to guarantee profitability (von Braun, 2013). Scarcities in land or labour may differ regionally, but also between households. Therefore, land- and labour-saving mechanisation pathways may also occur simultaneously within the same area. However, we can set apart a few mechanisation options that are less constrained by these factor endowments: simple equipment for transport (trailers), post-harvest operations (threshers) and irrigation (water pumps) have proven to be useful and profitable in many scenarios. They are relatively cheap and mechanise farm operations that are not particularly time-bound, allowing for higher utilisation rates and profitability (Baudron et al., 2015). Most importantly, the choice of tasks that are to be mechanised – and of the intensity of mechanisation – depend not only on aggregate factors but differ between households in the RWs. Different mechanisation pathways may thus open up simultaneously within the same region, or even village.

Mechanisation in SSA today

In the absence of more coherent data on the use of mechanisation in SSA's agriculture sector, levels of mechanisation are often equated with “tractorisation” for statistical purposes, estimating the number of tractors only. Although these data cannot give a comprehensive picture

of mechanisation in SSA – they do not include medium- to low-intensity mechanisation, most importantly draught animals – they can serve as a proxy and allow for a rough image of the state of mechanisation. Generally speaking, the overall number of tractors in SSA is declining, whereas in most other world regions the number of tractors has steadily increased over the last decades (see Table 2).

Table 2: Number of tractors in use			
Number of tractors in use			
	1961	1970	2000
Sub-Saharan Africa	172,000	275,000	221,000
Asia	120,000	600,000	6,000,000
Middle East	126,000	260,000	1,700,000
Latin America	383,000	637,000	1,800,000
Source: joyn-coop (n.d.), adapted from Mrema, Baker, and Kahan (2008, p. 10)			

In relative terms, too, the number of tractors in relation to cultivated land has stagnated or decreased in most African countries between 2000 and 2009, and remains generally quite low (see Table 3). Yet, Table 3 also illustrates the huge differences in mechanisation levels between individual countries in the region. In the absence of statistical data, it is estimated that the use of draught animals, too, is generally declining in SSA. The reasons for this decline are manifold, with droughts and diseases and the lack of veterinary services being among the most important ones (Baudron et al., 2015; Neubert et al., 2011). Estimates also suggest that at the same time, mechanisation in irrigation and processing has seen steady growth in SSA (Balse et al., 2015).

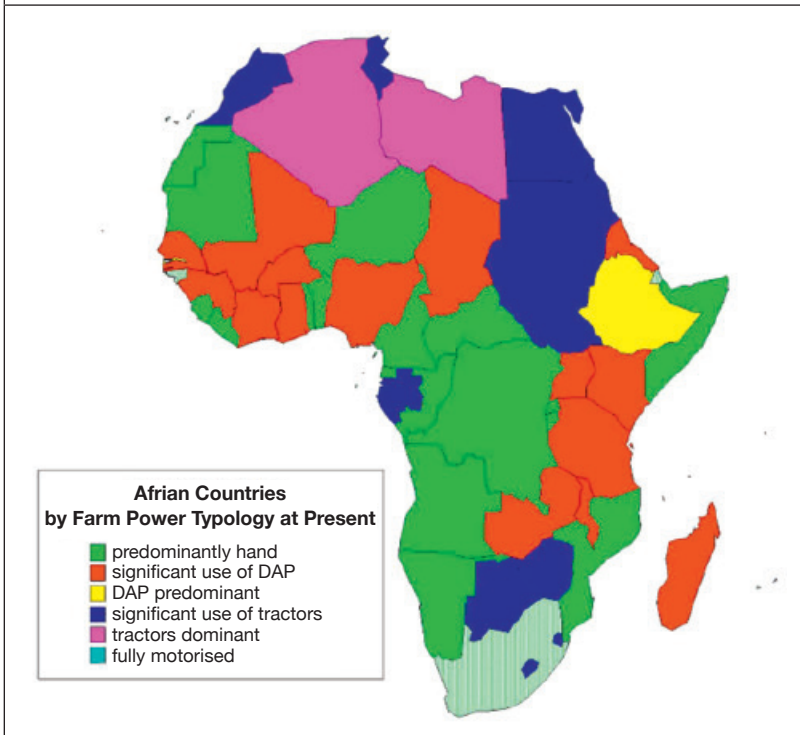
If we compare the use of the three main power sources (muscle power, animal power and machine power), we see that in 2006, human muscle power was still being relied on much more in SSA than in other developing parts of the world, whereas the use of motorised farm power is extremely low (see Table 4). This is in contrast to the fact that over wide areas of SSA – in particular in the extended cereal-root crop mixed-farming systems in West Africa – labour, not land, is the limiting factor for the amount of cultivated area (Garrity et al., 2012).

Table 3: Number of tractors per 100 km² of arable land in selected countries / regions		
Number of tractors / 100 km² of arable land		
	2000	2009
Côte d'Ivoire	30.0	32.1
Djibouti	80.0	46.2
Eritrea	8.3	8.3
Ghana	4.9	4.5
Kenya	24.9	25.2
Madagascar	2.7	1.9
Mali	4.1	2.2
Nigeria	6.5	6.6
Rwanda	0.7	0.5
Senegal	2.0	2.1
Sudan	7.3	13.2
Swaziland	219.8	87.1
Tanzania	19.0	24.7
Togo	0.3	0.6
Middle East & North Africa	159.3	159.3
South Asia	121.8	121.8
Source: joyn-coop (n.d.), adapted from World Bank (n.d.)		

Table 4: Sources of farm power for land preparation (% of total)			
	Human muscle power	Draught animal power	Engine power
Sub-Saharan Africa	65	25	10
East Asia	40	40	20
South Asia	30	30	40
Latin America and the Caribbean	25	25	50
Source: joyn-coop (n.d.), adapted from Kienzle and Sims (2006, p. 6)			

These figures show a severe lack of farm power in SSA (see Figure 5 for a more detailed breakdown on the country level), making farm power “a major limiting factor to productivity” (Baudron et al., 2015, p. 891) in many regions of SSA. Hence, there is a high potential for mechanisation to fill this gap and contribute to higher levels of farm productivity: “The availability of power determines the area under cultivation, the timeliness of operations, the effective use of other inputs and, ultimately, the productivity of the system” (Kienzle & Sims, 2006, p. 12).

Figure 5: African developing countries by farm power (2002)



Source: Clarke and Bishop (2002, p. 4) (excluding South Africa, as it is not considered a developing country)

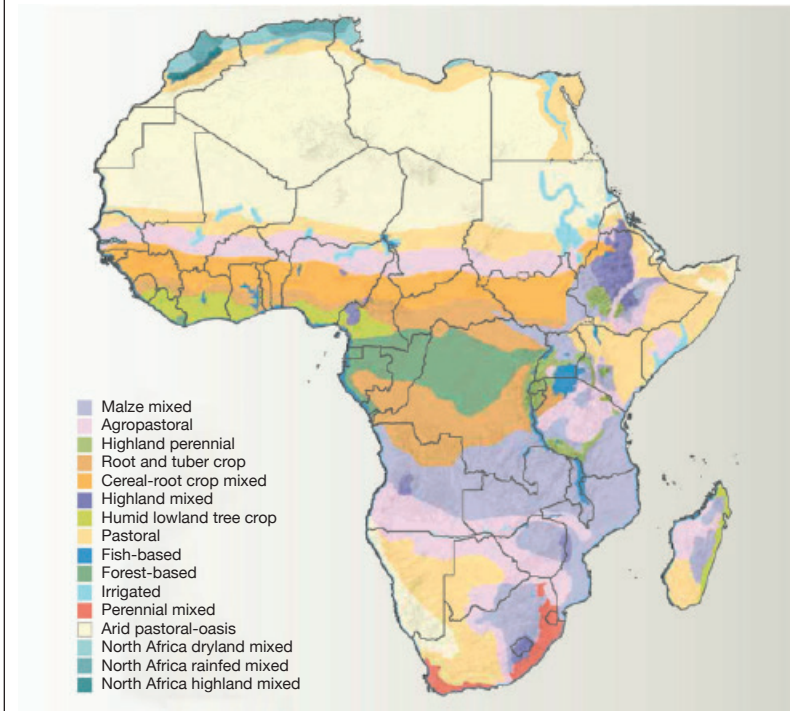
3.2 Barriers to successful mechanisation in SSA

Despite these necessities for mechanisation, some fundamental barriers in SSA remain, hindering its successful implementation. Much of the agricultural land in SSA can be considered marginal, as defined by Joachim von Braun (2013, p. 152): “Marginal environments are areas that have been relatively unfavourable for agricultural production due to one or more socioeconomic, technological, or biophysical constraints.” If mechanisation is to be successful, these constraints need to be considered, as do more specific obstacles to mechanisation per se. In turn, we consider agro-ecological, socio-cultural, regulatory-institutional, infrastructure and financial barriers. Not all of these barriers apply to all parts of SSA or to all RWs or mechanisation options, and we do point out where specification is needed.

Agro-ecological, geographic and climatic conditions are particularly challenging in SSA

The African continent is divided into a multiplicity of agro-ecological zones that each show comparable rainfall patterns, water availability and resulting growing periods, soils, latitude and temperatures. Farmers have adapted to these and other external conditions by employing certain farming systems (see Figure 6) with different combinations of crops, cropping cycles and growing patterns. These farming systems strongly influence farmers’ potentials and constraints for livelihood improvement through intensification, expansion or diversification and determine the suitability and opportunities for mechanisation options (Garrity et al., 2012).

African agriculture is constrained by vast areas of dryland, covering 43 per cent of the continent, as well as a high dependence of agriculture on degraded soils (von Braun, 2013). Most degradation has been caused by non-mechanised agriculture, and it is simply because much more land is degraded in SSA than mechanised. In other regions, small farm plot sizes, hilly, steep or stony terrain, and trees or stumps on plots make medium- to high-intensity mechanisation oftentimes unfeasible, at least in the short term, and do not allow for economies of scale. Profitability is further limited by short vegetation periods, resulting in low utilisation rates for many machines. In the humid tropics, some soils are unsuited for permanent crop production and require long fallow periods (or high input use), which makes the use of typical mechanisation equipment for land preparation unprofitable (Pingali, Bigot, & Binswanger, 1987). In the semi-perennial,

Figure 6: Farming systems in Africa

Source: Sebastian (2014)

perennial or multi-storied cropping systems often employed on these soils, opportunities for mechanisation are more limited and are mainly confined to on-farm transport of produce or inputs, and tree management. Many middle- and high-intensity mechanised technologies are not practically applicable in tree-based cropping systems – for example, for tasks such as ploughing or harvesting – making these systems heavily dependent on manual labour (Kienzie & Sims, 2006; Pingali et al., 1987). Another example is irrigation technology: it is only feasible and useful for improving yields where water for irrigation is available and accessible at crucial times in the growing cycle. Other tropical countries, such as Brazil and Indonesia, have shown that it is possible to crop these lands mechanically; yet, this requires specialised packages. In those areas where no additional land for the expansion of an

individual production area is available, large-scale mechanisation might not be an option (Balse et al., 2015; von Braun, 2013). Medium-intensity mechanisation with 2WTs or draught animals might overcome some of these obstacles, as they can prove profitable on much smaller plot sizes, and pose fewer requirements for clearing of stumps, stones and trees (Baudron et al., 2015). 2WTs have been very successful in Asia's wet and terraced paddy fields for ploughing, but they face problems when ploughing on Africa's drier and heavier soils under rainfed agriculture (Dixon, 10/2015). In SSA, their use is thus more or less confined to certain farming methods that do not require deep soil disturbance, such as CA (Baudron et al., 2015). Being quite versatile, they can also be used for other farm tasks, such as transport or powering processing machinery and water pumps.

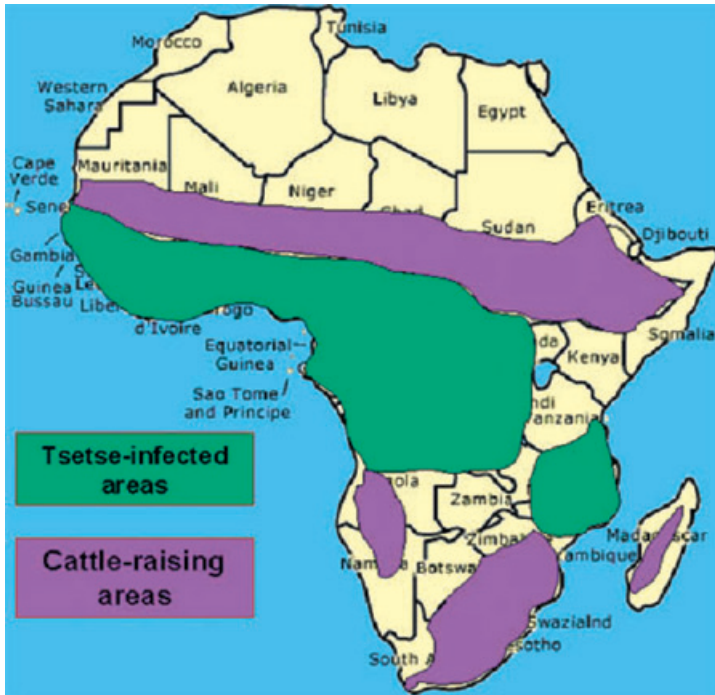
Case Study "FACASI"

The FACASI project has shown that adapted implementation of 2WTs can work in SSA, given adequate support and supply structures. See Case Study 2 in Annex 2 for a detailed description.

Similarly, animal husbandry and the use of draught animals (horses, most cattle) are heavily restricted in areas where tick-borne diseases or tsetse flies – a vector of trypanosomiasis – are prevalent (Kienzle & Sims, 2006). Vast areas in East and Central Africa are therefore almost entirely excluded from keeping livestock (see Figure 7), with most animals being concentrated in only a few regions of SSA (Baudron et al., 2015). A further restriction to draught animal power is their year-long need for large quantities of fodder, with reoccurring droughts and shrinking communal grazing areas posing serious challenges to farmers and pastoralists alike (Baudron et al., 2015). Where diseases and adverse climatic conditions make the keeping of livestock overly risky, motorised mechanisation becomes a more attractive option (Baudron et al., 2015).

Geographically, remoteness is a major limiting factor for commercial farming and, consequently, for mechanisation: "More than one third of all sub-Saharan rural Africans are so geographically and economically isolated from market towns that, at present, they are virtually condemned to a life of subsistence agriculture" (Livingston et al., 2011, p. 18). In the absence of profitable marketing opportunities, farmers will not produce much more than they can consume: "There is thus no motivation to adopt productivity enhancing technologies, particularly those external inputs which are costly

Figure 7: Tsetse fly and cattle distribution in Africa



Source: Hunt (2015)

and, in any event, are not likely to be available” (Livingston et al., 2011, p. 19). Even for less-isolated farming communities, distance can be a hindering factor when extremely high rural transport costs make market sales unprofitable for many crops (Livingston et al., 2011). This reduces the number of crops that are still profitable, despite the excessive transport costs for high-value crops such as spices, cotton and cocoa (Pedersen, 2007).

Socio-economic and cultural patterns affect the demand for and adoption of mechanisation

Extreme or enduring poverty keeps many farmers in RWs 3 and 4 from investing in anything but the most urgent farming inputs. Whenever farming activities can be performed manually, mechanising these tasks is usually

not an option for very poor farmers, and experiences from the past have shown that donated mechanisation equipment is likely to be sold, often due to the need for cash and absence of savings (Kienzle & Sims, mimeo); Delve & Twomlow, 10/2015). In SSA, the low purchasing power of many smallholders – aggravated by low producer prices – coincides with the comparably high costs of agricultural inputs and machinery (Shetto, 2007). These market imperfections work to the rural poor’s disadvantage and lead them to buy at high prices and sell at low ones: “The poor are thus adversely incorporated in the market – not the free, rational players that neoclassical theories would assume” (OECD, 2006, p. 53).

Additionally, many of the poor living in rural and remote areas in SSA, especially those in RWs 3 to 5, lack not only economic means, but often also education and literacy, and do not pursue longer-term prospects for their farms – the latter may also be due to real or perceived title insecurity. In 2013, more than one-third of SSA’s population was considered illiterate – most of them women – and literacy rates in some countries even range well below 50 per cent (Huebler & Lu, 2013). Yet, mechanisation requires more specialised farm management, including basic skills in accounting and financial transactions. The lack of technical knowledge often results in misuse of machinery and long down-times (Kienzle & Sims, mimeo). On the supply side, training for machine operators and mechanics is missing, and technical know-how and training are generally poor (Shetto, 2007). Finally, remoteness and low-incomes affect farmers’ experiences with new technologies. This may be an important impediment for mechanisation, as knowledge, understanding and user skills need to be built up.

The (rational) risk-averse behaviour of poor farmers discussed in Chapter 2 is another constraining factor for mechanisation: “[T]he need to minimize the possibility and impact of shocks undermines people’s ability to seize opportunities – notably by preventing or discouraging them from taking the risks involved in investing resources in pursuing the opportunities” (IFAD, 2010, p. 10).

In the absence of adequate insurance mechanisms, high- and medium-intensity mechanisation in most instances is a high-risk / high-return strategy for agriculture, promising high profits in case of success, but bearing the risk of high losses. This makes it an unattractive – or even unwise – option for many poor farmers in SSA, who are hesitant to “move up the ‘risk-return’ ladder” (Livingston et al., 2011, p. 14). Machines might break, and animals may die or be stolen; loans need to be repaid in any case, and working

capital needs to be financed with increasing returns from agricultural production. For many family-led farms, an investment in medium-intensity mechanisation means increasing commercialisation and specialisation, thus affecting two central risk-management strategies of family-led farms: livelihood diversification and extensive cropping. With commercialisation, more household resources will have to be invested into agricultural production, in terms of time and labour, fertilisers and pesticides. The latter are costly to purchase (if external) or to produce and transport (internally). In many instances, this may also require higher yielding crop varieties to pay off the investment in mechanisation – yet, modern varieties are often costlier and less resilient than traditional ones.

Highly diversified livelihoods (see Chapter 2) may also constrain the demand and potential for relatively cost-intensive mechanisation, when agriculture is not pursued as the main business, making large investments into the farm unprofitable from a household perspective. The same holds true for diversified cropping systems that complicate the usage of machinery and tools. Additionally, rural households' involvement in solidary family systems may lower the demand for mechanisation even further by setting negative incentives for wealth generation. Redistribution duties may also hold back farmers from saving money for the purchase or hiring of mechanisation tools, or might even force them to sell off assets. These barriers differ vastly between households in the five RWs, and between mechanisation options, accordingly.

Customs, traditions and religion can have a major impact on people's livelihoods, including their choices for – or even opposition to – certain tools, or mechanisation in general. Social and cultural characteristics thus need to be taken into account when planning or supporting specific mechanisation schemes. Many farming communities in SSA have a very long tradition in the use of certain tools or farming systems. In some instances, cultural or societal values have been formed around these practices, and, consequently, there may not be any desire to change them. Although, in most instances, women will appreciate a reduction of their work burdens, for example through the installation of water pumps, this may not always be the case; for example, in cases where women have limited occasions for social interactions outside their homes or workplaces, some of them may “appreciate the opportunity for social time afforded by certain activities” (Grassi et al., 2015, p. 17), even if this implies a higher work burden (Delve & Twomlow, 10/2015; Heyl, 10/2015). Specific barriers might also arise

out of religious beliefs and customs, for example when certain trees are declared sacred and may not be cut down, thus hindering the clearing of fields for tractor use (Brottom, 2005). In some regions or cultures, the use of certain animals such as oxen or the handling of machines is considered inappropriate for women – this may lead to non-usage, or even animal deaths, if the male household members are seasonally migrating elsewhere (Grassi et al., 2015). The gender-based allocation of plots and types of crops can further contribute to this problem and hinder potential efficiency increases (Alderman et al., 1995). Although these examples are selective and not suited to give a comprehensive picture of cultural patterns influencing mechanisation in all of SSA, they illustrate that households and individuals may base their decisions on reasons other than economic calculations.

The traditional socio-professional separation between pastoralists and arable farmers – often along ethnic lines – poses a barrier specifically to the adoption of animal traction in crop production. Where farmers are not used to livestock keeping, the adoption of draught animals brings additional challenges, requiring changes in the farming structure, choice of crops for fodder and training; but it is not unsurmountable (Brüntrup, 1997; Pingali et al., 1987). The purchase or use of larger machines may require collaborative approaches to guarantee profitability where households' plot sizes are generally small.

Regulatory-institutional barriers need to be overcome to facilitate investment

Experiences from Asia have shown that mechanisation heavily depends on a supportive institutional and regulatory framework. Yet, in many countries in SSA, institutions and laws are not conducive to mechanisation. High taxes and duties on imported machinery and goods make mechanisation equipment extremely expensive, whereas producer prices for agricultural goods are subject to high volatility and are generally quite low. At the same time, in some countries, selected strategic agricultural prices still are (and have been for decades in Africa) subject to national or regional price policies and interventions by national governments: in earlier decades to the detriment of agriculture, but in recent time they have been closer to world market rates or even at subsidised rates (Masters, 2011). However, instruments to influence prices have shown highly heterogeneous effects in terms of their impact on agricultural producers and smallholders (Minot & Dewina, 2013). Overall, experience indicates that the policies of, for

example, minimal producer prices or price subsidies can only be effective for smallholders in the long term if they are implemented in combination with capacity-development measures to increase productivity, which then can lead to a real, that is, market-based, price increase (UNCTAD, 2015).

Many parts of SSA lack proper land and tenure rights or suffer from inconsistencies in national and traditional rights systems. Yet, secured access to land has a crucial impact on mechanisation decisions, influencing both farmers' demands for mechanisation and their ability to acquire the financial means needed. Uncertainty about the future availability of their land will heavily restrict their likelihood to invest in such long-term improvements (Höllinger & Staatz, 2015): "Where farmers' rights to their land are insecure they are likely to opt for practices that yield the greatest benefits in the short-term, leading to underinvestment in land improvements that preserve the natural resource base for long-term productivity" (von Braun, 2013, p. 158). The lack of land and tenure rights not only influences farmers' decisions and aspirations; it also impairs their ability to acquire mechanisation equipment. Expensive as it is, most farmers will have to take on a loan to pay for it, as land is most often the only collateral they can offer to financial institutions. Yet, without legal title, finance providers will likely refuse to accept a farmer's land as security for a loan (FAO, 2008; IFAD, 2008):

For a successful transition from semi-subsistence farming to profitable, productive agriculture, land tenure must be secure and guaranteed by the state as well as by local laws and traditions. This will give farmers the security and confidence to invest in mechanization and other production enhancing inputs. (Kienzle & Sims, mimeo, p. 4)

In the short run, however, different solutions to the problem of lacking classical bankable collateral will have to be found. At present, most land ownership is not formally documented, and thus cannot be collateralised. It is also difficult for banks to sell collateralised land in rural areas, as formal land markets take time to evolve and become secure enough for financial institutions (Sacerdoti, 2005). In the past, value chain integration has proven to be a useful alternative form of collateral (Miller & Jones, 2010). Yet, regulatory barriers also exist for using other rural assets – such as livestock, movable assets such as machinery, or stored goods – as collateral, mostly because registration is not standardised and/or contract enforcement is a challenge (Höllinger, 2011).

Infrastructure and supply structures are consistently weak

One of the most prohibiting factors for mechanisation in SSA is the lack of key rural infrastructure. The lack of quality roads, fuel and electricity supplies, and communication and service infrastructure are barriers to rural development and access to markets, complicating mechanisation efforts on different levels and limiting its profitability for farmers and service providers.

Where villages and farms are poorly connected to market towns, farmers will find it difficult and costly to access agricultural dealers in order to acquire machinery and adequate high-quality farming inputs. With little local manufacturing at present, the supply of mechanisation equipment depends heavily on importation. Generally, insufficient supply and distribution makes mechanisation equipment more expensive. The lack of (access to) maintenance and repair services, as well as to fuel and spare parts, further exacerbates the financial risk farmers take when investing in mechanisation. They have to deal with long down-times and high additional financial requirements for broken or fuel-dependent equipment (Kienzle & Sims, mimeo). This is especially true for imported and high-intensity equipment, for which it can be difficult and tedious to acquire spare parts, and where local mechanics lack specific knowledge. Pingali et al. (1987) have found, however, that the main problem arises out of the lack of spare parts for high-intensity (imported) machinery, whereas technology competency in rural SSA develops fairly quickly if demand is high enough, as has been the case for medium-intensity machinery such as bicycles, maize mills and motorcycles.

On the local level, missing rural roads between remote and disconnected farms make the application and distribution of farm machinery time-consuming, prohibitively costly or even unfeasible – especially for large or bulky machinery such as tractors (Kienzle & Sims, mimeo). This lowers their utilisation rates and reduces profitability for their owners, which in turn makes adoption of mechanisation more unlikely. The profitability of mechanisation is further reduced when a lack of access to regional towns limits marketing opportunities for farmers to sell their surplus produce – thus hindering output increases from translating into higher income. The lack of storage, cooling and processing facilities adds to these problems, resulting in spoilage and pest infestation or forcing farmers to sell their surplus at peak times at below-market prices (Kienzle & Sims, 2014).

Financial barriers – access to finance is arguably the biggest constraint

For smaller and medium-scale farmers and rural entrepreneurs in SSA (RWs 2 to 4), access to finance is among the most important barriers to mechanisation (Breuer et al., 2015). Most farmers do not have enough income and savings to fund such investments. The lack of access to diverse financial services in general, and absence of medium-term loans in particular, are major restricting factors for an investment in mechanisation. Estimates by FinScope¹⁶ suggest that only 15–30 per cent of the rural populations in SSA have access to formal finance, and 30–60 per cent have no access to financial services at all (FinScope, 2014). However, these numbers include non-agricultural households, and many of the loans registered are for non-farm activities, thus for farmers of RWs 2–4, the situation is certainly even more dire. If financial services are available, they are often very costly, which rules out the use of a loan for less profitable investments.

Since mechanisation and the change it initiates also changes the risk patterns of farmers (see above), this must be adequately anticipated and managed. Access to better risk-management opportunities provided by the financial sector is therefore vital if the vicious circle of low demand / low supply is to be broken up (Brüntrup, 1996; Hatibu, 2013; Houmy et al., 2013). It is important to note that access to finance is not a specific bottleneck for mechanisation only, but that it also poses a general problem for the agricultural sector – especially in the case of larger term investments. Analysing formal access to credit by local banks for smallholders in the developing world (without China), the Initiative for Smallholder Finance estimates that less than 3 per cent of a US\$ 300 billion demand is currently covered (Initiative for Smallholder Finance, 2013b). Individual FinScope studies across SSA show that while access to finance is already lower in rural than in urban areas, access to agricultural finance is lowest. In Tanzania, for example, only 7.1 per cent of agribusinesses have access to formal banking loans, whereas access to various financial services by the rural populations in general lies at 27.6 per cent (FinScope, 2013b).

Given these shortcomings, creating a quality supply of financial services to SSA's rural populations is a key success factor for sustainable mechanisation. Chapter 4 elaborates in more detail on the difficulties of providing finance

16 FinScope surveys are nationally representative surveys of consumers or small business owners to investigate the way they source their income and manage their financial lives. FinScope surveys look at the use of – and demand for – financial services, including informal products (see <http://www.finmark.org.za>).

for mechanisation, and on promising approaches for increasing access to this specific kind of finance.

3.3 Intended and unintended consequences for food security: how can mechanisation have a positive impact?

3.3.1 Effects on people and land

When we evaluate the effects that mechanisation has on different aspects of farm life, it is important to keep in mind that mechanisation per se is neither positive nor negative – nor are traditional land use practices¹⁷ (FAO, 2011c). The same tool might improve food security for some while worsening the situation for others. Almost every effect is highly dependent on a variety of factors: Is it the right tool for the type of crop, farming system and soil? Does the farmer use it correctly and in combination with the right inputs? Who is using the equipment and how often? Is land scarce, or labour? Different farming systems may require specific tools and, vice versa, availability of tools may determine the feasibility of these farming systems.¹⁸

Given the diversity of these influencing factors and the multiplicity of mechanisation options, the task of exhaustively matching a certain tool with a specific effect, or vice versa, is an impossible one. Hence, what we do in this study is identify the main effects of mechanisation on people in the RWs, discuss their ambiguous impacts on livelihoods and food security, and raise awareness about the importance of taking into account the variety of factors that determine whether mechanisation can be successful with regard to the aim of enhancing food security in the region. In turn, we discuss the effects of mechanisation on the following dimensions: the quality of life, the productivity of labour and land, income and employment, gender, inequality, and environment and climate.

17 An example of unsustainable traditional land use is the custom of letting animals graze on the stumps in recently harvested plots. Although their dung is important for soil recovery, this practice will ultimately lead to soil compaction and erosion. Traditional farming systems with low productivity in areas with high population pressure might depend on the clearing of forests, expanding agriculture into ecologically important or fragile areas, or shorten soil-recovering fallow periods (World Bank, 2009).

18 Farming practices such as, for example, CA may require special equipment for practices such as ripping or direct seeding. Some crops may need special mechanisation tools as well, for example croplifters for groundnuts.

Improvement in the quality of life is a major driver and effect of mechanisation

Currently, most farm tasks are employed manually in SSA, being both labour- and time-intensive (Hatibu, 2013). It is estimated that, in East Africa, “[o]ver 90 per cent of the transportation of agricultural produce from field to home and/or local markets is done on the heads of women and children” (Hatibu, 2013, p. 4) – revealing both the high level of drudgery that current agricultural practices require in SSA, and a huge potential to increase efficiency.

One of the key social potentials of mechanisation is its promise to reduce this drudgery of manual farm work that is putting the young and more educated rural people off, contributing to the rural exodus in many parts of SSA. Making agriculture more attractive will slow down rural-urban migration and is key in improving agricultural production (Royal Society, 2009). Relieving farmers and labourers of arduous tasks such as field preparation also brings along major health effects. Indirectly, educational effects may arise when child labour is no longer necessary and income increases allow for the payment of school fees (World Bank, 2009). Mechanisation in transport can offer major mobility improvements to communities in remote areas, which in turn bring about better access to health and educational services, among other things (Crossley, Chamen, & Kienzle, 2009). Thus, mechanisation has the potential to contribute to an improvement in the quality of life, not only for the households directly involved, but for rural populations in general.

Productivity of labour and land may increase directly or indirectly

An increase in *labour productivity* (i.e. output per agricultural worker) is arguably the most important effect of – and reason for – mechanisation along all steps of the value chain. Tools or machines reduce labour time per unit of land or goods, thus requiring less time to fulfil a certain task. For example, grinding a family’s weekly amount of maize by hand takes 8–15 hours – a grinding machine can reduce this time to only 10 minutes (Kienzle & Sims, 2006). Primary tillage – being one of the most arduous and time-consuming farm tasks – requires about 500 hours of human labour per hectare (ha) compared to only 60 hours/ha using draught animals (Kienzle & Sims, 2006).

This time-saving effect of mechanisation has various implications. Many rural families have more land available than they can farm, due to labour shortages at peak times in the growing cycle. These labour bottlenecks restrict a household's overall cropping area. Where arable land is still available, increased labour productivity through the mechanisation of these labour-intensive and critical farm tasks allows for the expansion of crop production on additional land. Kienzle and Sims (2006) estimate that, on average, a farming family in SSA can cultivate 1.5 ha manually, 4 ha using draught animals, and 8 ha if a tractor is being used for ploughing. By breaking certain labour bottlenecks, usually during soil preparation, idle family labour can be used productively in other periods for other activities. Where mechanisation allows for an expansion of cultivated area, this will likely increase a farm's overall agricultural output (Brüntrup, 1996, 1997). Those households working their own plots – that is, those in RWs 3 and 2 – can also make use of their time saved by engaging in other farm activities such as processing, or by hiring out their labour for other employment opportunities. They may hence profit from higher farm or off-farm income (Kienzle & Sims, 2006).

The opposite side of this relation is that opportunities for spatial expansion depend not only on the availability or suitability of additional land, but also on the availability of labour for other manual and time-consuming tasks in the cropping cycle, such as uprooting, weeding and harvesting (Bishop-Sambrook, 2005; Brüntrup, 1997). Mechanisation is expensive, so for most smaller farms in RWs 2 to 4, it will only be financially feasible to invest in the mechanisation of a limited amount of farm tasks – most often field preparation only – while all other tasks will still be carried out manually (Tersiguel, 1995). But where additional manual labour is not available to work on larger cropping areas or handle higher yields, this kind of partial mechanisation can lead to labour bottlenecks in subsequent farm tasks, or in consecutive value chain steps such as transport, processing, storage and marketing (Brüntrup, 1996; Lele, 1975). Farmers may then not be able to profit from a machine's or tool's productivity effects, and may even face difficulties in paying back loans taken to finance the respective equipment. This potentially detrimental side effect highlights the importance of examining the economic questions of profitability on the individual farm level.

The mechanisation of specific farm tasks can also indirectly contribute to the higher *productivity of land*, that is, higher yields per hectare as

mechanisation radically reduces the working time needed per hectare, it also allows for better timeliness of time-critical field operations such as land preparation, weeding and harvesting. Timeliness is especially important in a context of shortening rainfall seasons: in semi-arid and semi-humid SSA, only a few days of delay can already result in high yield penalties (AGRA, 2014; Brüntrup, 1996; Sims, Röttger, & Mkomwa, 2011). Mechanising these time-critical tasks will thus allow for better adaption to short and irregular rainfall patterns, which in turn increases yields per hectare. This effect is also key in coping with the consequences of adverse weather events such as storms and floods, because production on destroyed or damaged fields can be taken up again much more quickly. Additionally, where mechanisation facilitates the adoption of agricultural intensification practices, land productivity can also increase (Kienzle & Sims, 2006). In SSA, there have been several institutional constellations (typically integrated crop or rural development boards) where mechanisation, intensification and marketing (including price policy) have acted together to support the adoption of the whole package and increase and intensify farming systems (cotton, groundnuts).

Another indirect effect on the productivity of land may arise out of mechanisation equipment that can be used for transport. Transport opportunities can lower financial and geographic access barriers to inputs such as improved seeds or fertiliser. On-farm transport options may allow for manure and fertiliser to be taken to the plots, including those farther away from the homestead, thus encouraging higher and more even input use, which in turn may improve overall yields (Baudron et al., 2015).

Irrigation techniques are especially valuable and have immediate effects on productivity. They can work as a catalyst for further mechanisation (FAO, 2008; Garrity et al., 2012). Small-scale irrigation may sometimes allow farmers in RWs 2, 3 and 4 to move from one harvest per year to up to three harvests, generating huge return effects, while being an affordable, sustainable and easy-to-use technology with potentially high utilisation rates (Obrist, 10/2015): “Low cost but effective technologies like the treadle pump can lift smallholder farm families out of poverty and into the cash economy” (Kienzle & Sims, 2006, p. 20).

Case Study “Pedal Pump”

Pedal pumps are a form of relatively cheap and low-intensity mechanisation, allowing farmers to increase their production and enhance their resilience towards heightened rainfall variability and droughts. See Case Study 3 in Annex 2 for a detailed description.

Income gains and employment generation vary according to mechanisation strategy

Effects of mechanisation on income are largely positive for those households directly engaged in mechanisation. Employment effects, on the other hand, can be more ambiguous, depending on the mechanisation strategy in question.

Income effects result mainly from a “combination of area, yield, and labor-savings effects” (Pingali et al., 1987, p. 110). The increases in labour and land productivity discussed above are thus expected to translate into positive income changes accordingly for the households concerned (Graf, Kayser, Klarsfeld, Bonsey, & Brossard, 2015), depending on availability of labour for other farm tasks, and on access to markets and value chains. Additionally, mechanisation can significantly contribute towards lowering food loss: in production, harvesting equipment allows for a timely and fast harvest. In subsequent steps, processing and storage tools and machinery can enhance the durability of produce and avoid spoilage, and transport opportunities facilitate (faster) access to (more distant and bigger) markets, enabling farmers to sell their surplus produce and achieve higher prices (Breuer et al., 2015).

These positive effects are confined, however, to situations where the choice of equipment fits existing circumstances. Thus, as some of our interview partners pointed out, mechanisation might aggravate food loss when equipment is not being matched with appropriate inputs. Harvesting machines, for example, may require the use of improved seeds so that all plants ripen at the same time and grow to a similar height (Miller 10/2015). Wrong handling of machinery – for example, processing machines – can also contribute to more food loss, with accordingly negative income effects (Heyl, 10/2015). Effects on income can also be negative for the individual machine owner if the equipment in question does not prove to be profitable. Machinery and equipment may be underutilised due to a lack of hiring

opportunities or short growing cycles. Long downtimes may occur if access to maintenance and repair services and to clean and affordable fuel or electricity is lacking. This may result in losses, loan repayment difficulties or even indebtedness when the investment proves unprofitable. It is important to keep these potential downsides in mind to stress the importance of factors such as knowledge and training, or availability of high-quality farming inputs and accessible sales markets that affect profitability of the mechanisation investment. Without income gains and a high positive rate of return, long-term adoption of the technology in question is highly unlikely.

Although these observations show that mechanisation can potentially add new risks to households, the right choice of equipment can also contribute to risk mitigation. Owners of draught animals and tractors in RW 2 may offer transport or hire services to other farmers year-round, opening up new opportunities to diversify income or reduce income seasonality (Crossley et al., 2009). The acquisition or use of small processing devices can reduce a household's dependency on unstable prices, as price volatility is highest for raw commodities, and more marketing channels are available for processed goods. Mechanisation may also mitigate the risk of investing in higher quality seeds and fertiliser; and labour-saving, low-tech mechanisation options, such as jab planters and animal equipment, make economic sense for smallholders and enable their transition into more resilient farming systems (Höllinger, 10/2015).

Effects on employment and income for those not directly involved in mechanisation are less positive. Mechanisation is a means for the substitution of capital for labour. As such, it can have a potentially large impact on rural employment by reducing the demand for – and value of – agricultural labour (Delve & Twomlow, 10/2015). This is especially true in areas where labour is abundant, resulting in negative income effects for agricultural labourers in RWs 3 and 4, at least in the short term. In other cases, the mechanisation of typical labour bottlenecks may enhance the labour demand for other farm tasks, with mechanised farms creating the demand for labour on the market (Pingali et al., 1987), offering employment opportunities to people in RWs 3 and 4. Employment effects of mechanisation on an aggregate level are thus ambiguous and depend on a variety of factors. Two examples may illustrate this.

In the case of Brazil, sugarcane harvesting was mechanised, switching from arduous, dangerous and labour-intensive manual cutting to high-

intensity, computer-controlled industrial harvesting machines within just a few years. This led to a wave of unemployment for the vast majority of unskilled sugarcane cutters. The government needed to step in and provide them with literacy courses or training – yet, only a minor share of the thousands of unemployed labourers could be reached by these measures (Garvey, Tyfield, & Freire de Mello, 2015). In Thailand, on the other hand, widespread mechanisation with medium-intensity machines through service providers had a different effect. Here, rural labour was scarce in the first place, because working in the urban textile sweatshops was preferred to manual agricultural labour. Medium-scale mechanisation with power tillers was able to fill that gap, and at the same time create attractive new rural employment opportunities in the mechanisation supply and service infrastructure (World Bank, 2009). From a macro-economic perspective, adapted medium technology constitutes a possibility for rural employment promotion in areas characterised by smallholder agriculture, although this might require subordination of economic growth goals to employment goals on an aggregate level (Braun, 2010).

These examples put a spotlight not only on the impact of the respective mechanisation intensity level, but also on aggregate contextual factors, such as land availability, population density and alternative employment opportunities. Where conditions are favourable, mechanisation offers a huge potential for job creation in value addition and in the repair and service infrastructure, although this most often requires higher educational levels than manual farm labour. Large-scale mechanisation, particularly in RW 1, however, may at times reduce rural employment opportunities further, but it can also generate new jobs, with the strongest effects being for the unskilled in RWs 3 and 4 (Keeley, Michago Seide, Eid, & Lokaley Kidewa, 2014).

Mechanisation effects on women are crucial, but hard to predict

In SSA and elsewhere, agricultural labour division occurs often more or less along gender lines (see Chapter 2). Accordingly, mechanisation can have both positive and negative effects on women by reducing or increasing their work requirements and bargaining power, thus mirroring the ambiguous social effects that mechanisation can have on rural households. Women will hence have to be an integral part of mechanisation strategies to avoid potentially negative effects.

Labour-saving technologies, especially in processing – such as mills and water pumps – can reduce women’s work burden and time poverty, thus enhancing health and food security for the women themselves and other household members.¹⁹ Yet, often the men’s task of primary land preparation is mechanised first – because it is one of the most arduous, time-consuming and critical tasks, and because men most often decide about farm investments. Where additional land is available, this mechanisation step will more often than not lead to an expansion in cultivated land. Subsequent tasks (weeding, harvesting, processing) that are still carried out manually mostly by women will therefore require more time and labour, thus worsening women’s work burden and time poverty (Tersiguel, 1995; van Eerdewijk, Danielsen, Hailemariam, & Mukewa, 2015). In a study on mechanisation in Burkina Faso, McCauley (2003, p. 15) concludes: “The strict separation of tasks between men and women precludes the possibility of reallocating to men the extra harvesting labor that tractor-tilled fields create, so that tractors actually have a harmful, exploitative effect on female laborers.” For a previous study in Burkina Faso, it was counted that women on mechanised farms worked 25 days more per year, whereas men’s amount of working days remained the same for manual and mechanised households (Tersiguel, 1995, p. 260). Where income from agricultural production is under male control, this may also lead to women rejecting to provide the additional work, so that “projects that require additional female labor but provide the remuneration to the male household head may fail” (Doss, 1999, p. 20).

Although high levels of drudgery are usually considered to be one of the major drivers of the demand for mechanisation, “women’s high labour burden does not translate into the articulation of a demand for – and adoption of – mechanisation due to the complex interplay of values and assumptions, access to and control over resources, and intra-household decision making” (van Eerdewijk et al., 2015, p. 52). Moreover, where mechanisation comes along with higher prestige and new opportunities for income generation – such as larger motorised processing machines – or where traditionally female crops see significant yield increases, this can lead to a shift of women’s work and responsibilities into the male domain. In turn, this may also deprive women of their income sources and the respective intra-

19 Many of those mechanisation options most relevant to women in rural SSA fall into the household sphere only, or are part of the rural non-farm economy. They will therefore not be covered in our study, despite their potentially important effects on food security.

household bargaining power, aggravating existing dependency structures (Alderman et al., 1995; Doss, 1999; van Eerdewijk et al., 2015).

Due to these complex and often unforeseeable effects that mechanisation can have on rural women's lives and gender relations in SSA, it is crucial to put a special focus on women in future mechanisation projects, and to involve the women concerned in planning and implementation accordingly.

Mechanisation can foster inequality in incomes and land distribution

Especially when mechanising agricultural production with high-intensity tools, and in regions where the land barrier has been reached, questions of land consolidation and inequality become an issue (Friends of the Earth International, 2015; Liversage, 2010). In some cases, smaller farmers merge their plots in order to make hired ploughing services with tractors cheaper and more easily feasible – a form of voluntary land consolidation that benefits farmers and service providers alike (Agwe, 10/2015). Yet, in other instances, larger farmers who own tractors or draught animals will try to get more land under cultivation – sometimes taking it by force from others, or by bidding higher for it – fuelling a tendency of shrinking numbers of farms with higher concentration effects and crowding smaller farmers out of agriculture (McCauley, 2003; Pingali et al., 1987; Peltzer, 09/2015). If these smaller farmers do not have other employment opportunities, they may become worse off than before. On the other hand, if they drop out due to pull (employment opportunities) factors and there is no land market plus mechanisation, production capacity of the rural area will shrink.

In any case, higher-intensity mechanisation comes along with structural changes and will have impacts on societal equality patterns. It will offer development opportunities for some and disadvantages for others. Income inequality in rural SSA is already extremely high, with Gini-coefficients close to 45 per cent (World Bank, 2015c). Hence, new questions will arise from new mechanisation efforts: Does increasing agricultural production necessarily have to go hand in hand with higher inequality of land and income distribution? Should land be consolidated to facilitate machinery use or should machines be adapted to smaller plots to offer access to mechanisation for smaller farmers, too (Baudron et al., 2015)?

The transformation process in Turkey in the 1970s illustrates how mechanisation can foster increasing levels of inequality: following a logic of family needs and the desire to reduce drudgery and gain prestige,

tractors were often partly financed from remittances. Still, they transformed the economic mode of production, farming practices and social relations. Responding to the economic pressure of the tractors, farmers started to act more like entrepreneurs and joint work was substituted by service provision against payment, which transformed (and monetised) social relationships, too. Tractor owners either started to work as service providers or increased their production. In the long run, a clear concentration of capital and land by tractor owners could be observed (Gohl, 1983).

In the course of large-scale mechanisation projects, land has also been given to or taken by foreign investors. Large-scale land acquisitions are not always or exclusively negative for the rural populations, but most entail some genuine problems (Brüntrup, 2011; Kleemann & Thiele, 2014). Where smallholders are deprived of their land for own agricultural production, structural dependency and vulnerability to shocks may grow, because “[t]he right to food in rural areas often still translates into having access to productive resources for agriculture” (Brüntrup, 2011, p. 33). Mechanisation-facilitated agricultural expansion may also take away grazing areas of pastoralists, forests used by villagers for firewood collection or areas that serve social or ecological purposes (Livingston et al., 2011). Yet, land acquisitions are not confined to foreign investors but can happen on any scale: “[L]and grabs are carried out by national and local elites, competing land users (pastoralists, crop farmers), and land grabs within families” (Liversage, 2010, p. 5). Most recently, evidence has been found for medium-scale African investors controlling more land than foreign investors (Chapoto et al., 2014). Local elites may also serve as facilitators for foreign investors, especially where there are legal constraints to foreigners purchasing land (Brüntrup, 2011). On the other hand, such large investments can create massive amounts of jobs if the right crops and (processing) technologies are chosen. Particularly effective are combinations of nucleus and outgrower systems in creating spillover to smaller farms from large ones, including mechanisation, but also a whole range of other services, knowledge, input supply and market access (Brüntrup et al., 2016). Again, it is not mechanisation per se but the circumstances and embeddedness that determine final overall effects.

High-intensity mechanisation in areas otherwise still characterised by manual farm power may strengthen the dependence of small farmers from larger, mechanised farmers through unequal exchanges of labour. This kind of mechanisation has also shown to contribute towards greater income inequality and social tensions (McCauley, 2003; Tersiguel, 1995;

World Bank, 2009): “When new technologies require more capital inputs, mechanization, or high levels of education, these requirements may disadvantage smaller farms” (Hazell et al., 2007, p. viii). Evidence from Brazil shows how devastating these effects can be: “Some of the region’s indigenous peoples and many early settlers – smallholder farmers as well as landless farm laborers – lost their lands, livelihoods, and in some cases their lives as the result of the expansion of large-scale mechanized agriculture” (World Bank, 2009, p. 139). In Thailand, however, where lower-intensity mechanisation and commercialisation took place on the smallholder level, the concentration of incomes decreased, absolute incomes rose for all and employment was generated in downstream value chain steps (World Bank, 2009). Small- to medium-intensity mechanisation is thus more likely to constrain the risk of large-scale land grabs and land consolidation, and offer mechanisation options to a greater share of rural people.

Heterogeneous agro-ecological effects

The environmental effects of mechanisation are ambiguous and depend on the mechanisation tool or intensity in question, as well as on a variety of contextual factors. The example of irrigation technology illustrates this: if not properly managed, irrigation may account for some serious environmental damages, which in turn reduces the soil’s suitability for agricultural production. Soil depletion through salinisation, soil erosion or washed out nutrients can be direct effects of irrigation, especially through improper handling or a lack of drainage. Larger irrigation schemes may additionally threaten biodiversity or reduce wetlands (FAO, 2011c). Depletion of water reservoirs and damage to their environmental functions are other risks of irrigation. On the other hand, however, irrigation can help to slow down agricultural expansion, thus protecting biodiversity. At the same time, irrigation counts as an important driver of productivity-enhancing farm investments, because “[w]ithout adequate water, farmers have little incentive to invest in quality seed and inputs” (FAO, 2002, p. 2). Effects of ploughing are equally ambiguous: depending on the kind of plough and its usage, the type of soil, climatic conditions and farming system, usage will at times cause soil erosion and degradation, whereas at other times it may facilitate the absorption of water and nutrients, thus protecting soils from degrading and eroding (AGRA, 2014; Kienzle & Sims, 2006; Pingali et al., 1987). This calls for special attention to the potential downsides of certain mechanisation strategies or tools, and on trade-offs between ecological and economic effects that may sometimes be unavoidable.

It is important to note, however, that traditional agricultural practices, too, can have major negative impacts that need to be considered as a counterfactual scenario to mechanisation. This scenario shows that traditional land use has frequently led to a significant degradation of soils. Often, chronic poverty prevents smallholders in RWs 3 and 4 from using fertiliser, resulting in soil mining, that is, the long-term exploitation of soils without nutrient recovery. In turn, this will lower productivity, leading to the “self-reinforcing feedback between low soil fertility and chronic poverty” (Barrett & Bevis, 2015, p. 907). Larger and more prosperous farmers, on the other hand, tend to mine soils less and reconstitute nutrients lost through harvests with mineral fertilisers; however, the link is not straightforward and depends on combinations of technologies and contexts (Drechsel, Gyiele, Kunze, & Cofie, 2001; Nkonya, Pender, Kaizzi, Edward, & Mugarura, 2005). Soil degradation is therefore not solely a problem of technology, but “is likely to be most severe where the returns on investments in land improvement are lowest” (von Braun, 2013, p. 157). Balancing the diverging effects of mechanisation and non-mechanisation is thus challenging and very context-specific.

Obviously, medium- and high-intensity mechanisation will have *climatic* effects in the form of increased emissions of greenhouse gases (GHG). This may happen directly, for example through the use of draught animals (methane emissions) or energy use in agricultural machinery (CO₂ emissions), or indirectly, for example where mechanisation incentivises land conversion to agriculture through deforestation or burning of savanna, destroying important carbon storages. Estimates for 2011 indicate that the indirect effects may be a more serious problem, with burning accounting for more than 20 per cent of agriculture-related GHG emissions in Africa. Livestock (enteric fermentation and manure left on pastures) create nearly two-thirds of Africa’s agriculture-related GHG emissions, yet these numbers do not indicate the percentage of draught animals in overall livestock numbers. Emissions from on-farm energy use, however, were rather insignificant in comparison – both on the regional and global levels (Food and Agriculture Organization Corporate Statistical Database, 2015), and per capita emissions in SSA are among the lowest in the world.

Environmental damages are often associated with large-scale high-intensity mechanisation for mainly export-oriented agriculture in RW 1 (Collins & Chandrasekaran, 2012; FAO, 2011c; Tersiguel, 1995; World Bank, 2009). The adoption of high-intensity machinery often fosters monocultures or reduced rotations, and is linked to specialised seeds that meet certain

uniformity standards and high fertiliser and pesticide use (Brüntrup, 2011). Where farmers have developed traditional long-term soil-improvement systems, such as fallows, mechanisation may also lead them to abandon these practices, due to an increased need for cultivatable and uprooted land (Tersiguel, 1995). Large machinery makes land consolidation and expansion on previously uncultivated land not only cheaper and feasible, but sometimes even economically necessary to guarantee profitability. A key determinant of whether this expansive effect of high-intensity mechanisation results in deforestation is the prior use of the land as farm- or forestland. Where forested land is still abundant, deforestation is most likely, as was observed in a case study in Benin, where loss of biodiversity and carbon storages through deforestation and land clearing were the immediate effects of the large-scale, high-intensity mechanisation of cotton plantations (Brottom, 2005). Although smaller farmers, too, are important drivers of deforestation in SSA (Rudel, 2013), larger farms or investors “have more radical means to clear the landscape” (Brüntrup, 2011, p. 34).

Medium-intensity mechanisation, like 2WTs or draught animals, might set technological limits to land expansion and come with less ecological intrusion, as most equipment can be used in smaller and more fragmented plots and does not require as much clearing and levelling (Baudron et al., 2015). Mechanisation is also being promoted as a means to facilitate agricultural intensification “to relieve pressure for agriculture to expand into marginal zones” (World Bank, 2009, p. 163). Yet, evidence for this “land sparing” premise has so far been weak, and it has been shown that increased yields through (sustainable) intensification²⁰ efforts will rather encourage farmers to bring more land under cultivation (Collins & Chandrasekaran, 2012). Sustainable intensification methods, such as CA, are also hoped to contribute to soil conservation and adaptation to climate change. Due to their requirements for specific methods of land preparation, such as ripping, or the need to transport and apply large quantities of manure, these practices would often be too labour-intensive, arduous or time-consuming to employ manually. By filling this particular power gap

20 “Sustainable Intensification” is a relatively new yet controversial paradigm of “producing more outputs with more efficient use of all inputs – on a durable basis – while reducing environmental damage and building resilience, natural capital and the flow of environmental services” (Montpellier Panel, 2013, p. 11). The concept is being promoted by various donors and practitioners today (e.g. FAO, 2011a; Royal Society, 2009; Vergnani, 2013), and criticised by others (e.g. Collins & Chandrasekaran, 2012).

with adapted tools, mechanisation may allow for the adoption of more sustainable farming systems (AGRA, 2014; Baudron et al., 2015; Sims & Kienzle, 2015). National regulations and their strict surveillance would be necessary to prevent mechanisation-facilitated expansion into protected areas, as proposed in international treaties such as the Aichi Biodiversity Targets (United Nations Environmental Programme, 2010).

We have seen that effects of mechanisation on people and land can be highly ambiguous and hard to predict. In those cases where mechanisation is not inhibited by external barriers or misuse, mechanisation will likely have a positive long-term impact for those households and enterprises in RWs 1 to 4 that are directly involved. Increases in output and income and a reduction of drudgery are the most important effects for this group. Other rural households in RWs 3 and 4 will be most affected by changes in employment opportunities – be it for the better (through additional labour demand and jobs in the service infrastructure) or for the worse (through the substitution of manual labour or additional burdening of women with arduous tasks). Environmental effects are equally divided and sometimes contradictory. Although the respective outcomes depend hugely on external factors, low- and medium-intensity mechanisation seems to be a more promising strategy for reaching larger shares of the rural populations, with less potential for adverse social and environmental effects. If we consider the counterfactual scenario of a continuation of the status quo, the mechanisation of agriculture will most likely be necessary to cope with the various challenges SSA is currently facing. Nevertheless, trade-offs between positive and negative socio-economic and agro-ecological effects will have to be carefully weighed for each specific setting.

3.3.2 Implications for food security

Food security is itself a complex and comprehensive concept with diverse entry points. For a person to be food secure, four main pillars have to be fulfilled simultaneously:

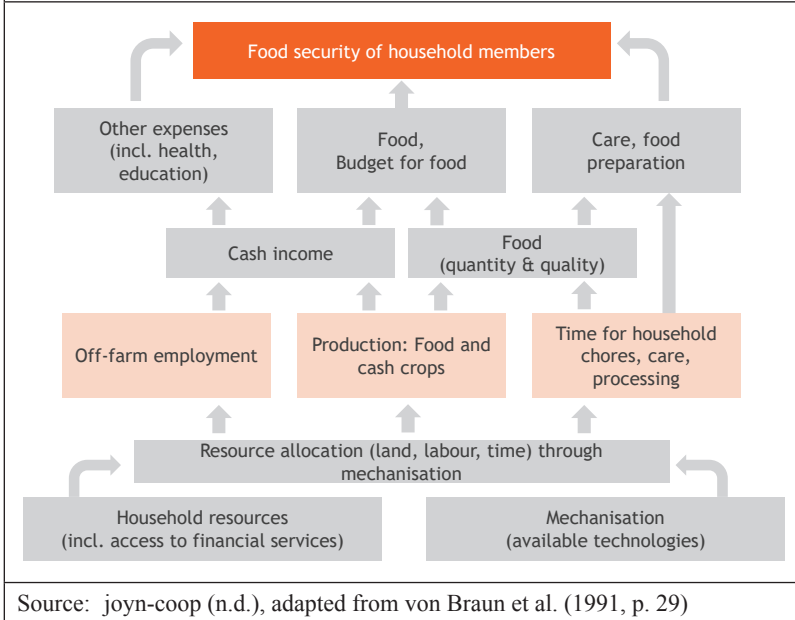
- **Availability** is the physical presence of food on an aggregate level. Local production is one of several influencing factors, but imported and exported food goods have to be calculated in as well.

- **Access** to food on a household or individual level has to be secured both physically and economically. Food availability on the national or global level does not automatically translate into individual access opportunities.
- **Utilisation** requires that the human body be able to make use of the food and nutrients consumed. This factor is influenced by nutritional diversity, feeding practices, food preparation and intra-household food distribution.
- **Stability** means that for food security to be achieved, all three pillars have to be secured over time and be resistant to external shocks such as political instability or extreme weather events (European Commission-FAO Food Security Programme, 2008).

More recently, specific focus has been put on **nutrition** as a necessary component of food security, with the phenomenon of “hidden hunger”²¹ revealing the insufficiency of the previous conceptual focus on mere caloric quantity (FAO et al., 2015; IFAD, 2014b). The socio-economic and agro-ecological effects of mechanisation can influence food security on one or several of the four abovementioned pillars, and some mechanisation options will also touch on nutritional aspects of food security.

For most households in rural SSA, food security depends almost exclusively on own involvement in agricultural activities – be it directly for subsistence production, or indirectly through income from surplus sales or labour on other farms. Effects of mechanisation on food security will therefore be plentiful and result directly or indirectly from the agro-ecological and socio-economic effects discussed above, but can also be attributed to more specific effects regarding food loss. Figure 8 illustrates the different paths through which mechanisation may influence food security from a household perspective. Mechanisation may alter the resource allocation of household members in either off-farm employment, agricultural production or other household tasks. This affects both food and cash income streams, which in turn has implications for the food security of household members.

21 “Hidden hunger” describes micronutrient malnutrition, that is, deficiencies as a result of the lack of nutrients in a diet or during pregnancy (FAO, IFAD, & WFP, 2015, p. 10).

Figure 8: Influences of mechanisation on food security for agricultural households

Source: joyn-coop (n.d.), adapted from von Braun et al. (1991, p. 29)

Questions of production of and access to food are inextricably interwoven into a vicious circle in SSA, because those most vulnerable to food insecurity are basically the region's many smallholder farmers and agricultural labourers (FAO et al., 2015), corresponding to RWs 3 and 4. They are producers and consumers of food at the same time, influencing food availability directly through the production of and, indirectly, the demand for food. Farmers will only be incentivised to produce more if there is sufficient effective demand; yet in rural SSA, that demand mainly depends on agricultural incomes (Pretty, Thompson, & Hinchcliffe, 1996).

Availability of food is not equivalent with local food production, as the former is influenced by many external factors, most importantly trade and post-harvest food loss (Pretty et al., 1996). Yet, in the current institutional and demographic setting, an increase in production of food crops, particularly in SSA, seems imperative (Royal Society, 2009): "Arguably, the most sustainable choice for agricultural development and food security is therefore to increase total farm productivity in situ, in the

developing countries that are the most in need of greater food supplies” (United Nations Environment Programme-United Nations Conference on Trade and Development [UNEP-UNCTAD], 2008, p. vii). This is especially true where countries have difficulties addressing domestic production shortages with increased imports, where local staple foods are not traded internationally, or where poor infrastructure makes food transport to remote areas overly costly (World Bank, 2007). Mechanisation has the potential to contribute to higher national self-sufficiency in food production, thus increasing food availability, both on the domestic and local levels. This holds especially for those farms catering to local or national markets (RWs 2 & 3), but less so for mechanised agriculture oriented towards export markets. Yet, mechanisation has proven to be most profitable and cost-effective for farmers in all RWs if cash crops (food or non-food) for export or biofuel production make up a larger share of their overall production, because of better marketing opportunities and higher market prices. This may lead farmers to neglect subsistence or staple crop production. In conditions of insecure income and unstable food markets, this trend can potentially have adverse effects on the availability of staple crops, on nutritional diversity and on food security for the respective households (Camagni & Kherallah, 2014; McCauley, 2003; Paulitsch, Baedeker, & Burdick, 2004). In other instances, however, cash crop expansion is a driver for higher food production through spillover effects – notably in mechanisation and other productivity-enhancing technologies – infrastructure and institutional improvements (Brüntrup, 1997; Goetz, 1993; Negash & Swinnen, 2013; Theriault & Tschirley, 2014; J. von Braun & Kennedy, 1994).

Access, on the other hand, relies not only on economic means to buy or produce food, but also on physical access to markets, and on “entitlements” that are defined culturally on a community or household level (Pretty et al., 1996): “[W]hat is important is who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it” (UNEP-UNCTAD, 2008, p. viii). The most obvious lever of mechanisation for food security in SSA is via increases in agricultural output on the farm level through yield improvements and reduction of food loss. Higher output of food crops enhances availability of and access to food, not only for the households using mechanisation, but for the whole rural community. Where production increases result in cheaper local food prices, this will indirectly enhance economic access

to food for those rural stakeholders who are net buyers of food– with the highest food security effects being for the landless poor of RWs 4 and 5 as well as urban consumers (World Bank, 2009). However, for producers in RWs 2 and 3 who generate their income from sales of surplus production, lower producer prices will also reduce initial income gains from higher levels of production. These effects depend largely on the elasticity of the demand for agricultural products, which is also influenced by transport opportunities to bigger markets (Pingali et al., 1987). The effect of mechanisation for cash crop systems on food access depends – in addition to the spillover to food production (see above) – on income effects and the use of that income.

Income increases through surplus sales, efficiency improvements and new employment opportunities in services and value addition have the highest potential to exert positive effects on food security for the farmers, processors, service providers and land labourers of RWs 2 to 4: “Today, agriculture’s ability to generate income for the poor, particularly women, is more important for food security than its ability to increase local food supplies” (World Bank, 2007, p. 95). The income and employment effects discussed in Section 3.3.1 can thus translate, with reservations, more or less directly into effects on food security. Money is fungible and can be used to enhance not only economic access to food, but also to pay for other services such as education and health, which in turn affect the **utilisation** pillar of food security. Where mechanisation in processing and storage increases the durability of food and reduces food loss, food security will be improved through the availability of higher food quantities and better **stability** throughout the growing cycle. This will enhance physical access for subsistence consumption, but also economic access, when farmers can increase their incomes by selling their produce later at higher prices (Breuer et al., 2015; World Bank, 2011a). Some technologies in harvesting, processing and storage will also contribute to the better quality of produce, allowing farmers to sell at higher prices, too (Breuer et al., 2015). Mechanisation in transport can have an additional impact on the access component of food security by opening up opportunities for market access, thereby increasing possibilities for income generation through market sale and post-harvest loss reduction, but also facilitating food purchase at local markets (Baudron et al., 2015; Schmid, Bartholdi, Moosmann, Czeh, & Engelskirchen, 2013).

Yet, with income increases being the main lever for food security, mechanisation can also have adverse effects, not only for the individual households concerned, but also on an aggregate level. If not enough employment opportunities are created in service and value addition to accommodate unskilled rural labourers in RWs 3 and 4, job losses on mechanised farms will leave them with less income, and hence, worsened economic access to food. For those directly engaged in mechanisation, profitability of a mechanisation investment may fail, with the debt burden lowering food security for the whole household. Moreover, although more income can allow households to access more food in theory, this is not always the case in practice when mechanisation changes intra-household structures of resource allocation and power:

[I]mproved incomes do not always result in improved family welfare, given the tendency for men to control cash crop income. Indeed, far from improving welfare, the rise of commercial agriculture has been seen to increase the vulnerability of women and children as their former productive assets (that is, land and labor) and activities become diverted to commercial agricultural activities over which they exert only limited control. (World Bank, 2009, pp. 162–163)

Where women lose own income or their intra-household bargaining power, food security for the whole household may be reduced, but especially for the women themselves and for their children (Doss, 1999; FAO, 2011b; van Eerdewijk et al., 2015).

Land consolidation – associated mainly with high-intensity mechanisation – will have major food security effects for stakeholders in RWs 2 to 5. There is some evidence for growing competition between cash crops for export and staple foods for local consumption, with local elites or foreign investors using their power to access prime locations (Paulitsch et al., 2004). Farmers who are displaced in the course of mechanisation-facilitated land consolidation lose both physical and economic access to food. In SSA, it is disproportionately smallholders (RW 3) who are threatened by this kind of development (Balse et al., 2015; IFAD, 2008; McCauley, 2003). The race for land has also led to the cultivation of previously communal land and forests with critical social and economic functions, limiting the benefits of income generation for some groups who rely on forest products for income and food (Tersiguel, 1995): “The food security function of edible roots and wild fruits as well as the importance of medical plants will continue to be

important for these rural populations even after agricultural productivity increases” (Baumgartner, 2015, p. 159).

However, there is also evidence for a positive correlation between cash and food crops if mechanisation, fertiliser or organisational progress induced by cash crops spill over to food crop production (Brüntrup, 1997; Govereh & Jayne, 2003, Herrmann & Grothe, 2016). Thus, if land-based investments lead to technological and financial spillovers – for instance from contract-farming or learning – the overall result could be an increase in food crop production (if that is what the farmer wants).

The effects of mechanisation on **nutrition** are equally ambiguous, because “[h]igher levels of production and income alone have a limited impact on improving nutrition” (IFAD, 2014b, p. 5). Where mechanisation enables and enforces monocultures and cash crop production, and where this reduces availability of – and access to – food crops, it can have negative effects on nutrition by impoverishing the diets of subsistence farmers and local communities (Tersiguel, 1995). Improved efficiency in processing and storage, on the other hand, can contribute significantly to the preservation of food’s nutritional value (IFAD, 2014b). Where mechanisation facilitates the adoption of more sustainable farming systems or irrigation, it can enhance, not diminish, the diversification of food crops – provided that behavioural and cultural patterns follow these changes accordingly (FAO, 2002; IFAD, 2014b). Also, where higher cash crop incomes lead to more purchases of nutritious food, mechanisation will be beneficial. After all, culture and behaviour determine whether a higher potential for nutrition (through availability and access) translates into better nutritional practice (von Braun & Kennedy, 1994).

Considering all potential effects, we can state that food security is likely to improve for those households using mechanisation successfully (i.e. profitably) on their own farms. Yet, for those who are not using mechanisation themselves, the picture is more ambiguous. Where mechanisation is confined to RWs 1 and 2, food security for RWs 3 and 4 depend largely on the creation of adequate employment opportunities with the according income effects. Yet, where there is a significant danger of negative effects, such as unemployment or displacement, a special focus should lie on the mechanisation of smaller production units – not only because they tend to be the poorest and have the biggest potential for productivity increases, but also because these family farms are key to

improving rural livelihoods and poverty reduction (Hazell et al., 2007): “They can create large amounts of productive employment, reduce rural poverty, support a more vibrant rural economy and help reduce rural-urban migration” (OECD, 2006, p. 30).

3.4 Success factors for sustainable mechanisation

From the above analysis of the effects, we can deduce some success factors for sustainable mechanisation: technology needs to be adapted to local conditions, and mechanisation requires an enabling environment and needs to be demand-driven and profitable. Often, efforts to mechanise may need to be combined with other components (package approach) to ensure good developmental effects and avoid negative ones.

Mechanisation options have to be adapted to local needs and constraints

Lessons from the past have shown that it is medium-scale farmers, that is, mainly those in RW 2, who are key players in the adoption of mechanisation (Mrema, 2011). Generally, in most of SSA, smaller machinery would allow the region’s many stakeholders in RWs 3 and 4 – and also 2 – to adapt better to mechanisation. For example, small-sized tractors, or motorised tillers, could be purchased by farmers in RW 2 and hired out to those in RWs 3 and 4. Although in SSA smallholders are considered to be important drivers of deforestation themselves (Rudel, 2013), medium-intensity mechanisation would also set technological limits to the expansion of agricultural land into protected areas (Hancox, 2011; McCauley, 2003): “The promotion of individual technologies, such as animal traction and/or tractors for land preparation, should give way to flexible strategies for promoting diverse types of mechanical technologies that are compatible with local economic, social and developmental conditions” (Mrema, 2011, p. 26).

Labour-intensive and tedious farm tasks are usually the first to be mechanised. When new sources of power become available, they are at first used only in selected operations for which their comparative advantage is high (Pingali et al., 1987). Land preparation will probably be the farm task most in need of mechanisation, as it is currently the task most affected by labour shortages. When mechanising land preparation, however, the mechanisation of subsequent tasks should follow suit in order to avoid the exploitation of female family labourers

and to guarantee that mechanisation will translate into higher yields and income (McCauley, 2003). Other mechanisation options that promise major positive effects are transport, irrigation and processing (Pingali et al., 1987).

Mechanisation has to be profitable

Where the demand for agricultural products is lacking – because of low population densities and a lack of access to markets – farmers will not have an incentive to produce more, hence, their motivation to invest in farm equipment will be limited (Camagni & Kherallah, 2014). Experience in Asia has shown that product prices need to be sufficiently high for farmers and entrepreneurs to see a potential for generating income through surplus production, and to trigger the demand for mechanisation – sometimes through minimum producer prices (Hancox, 2011; Singh, 2011).

Most mechanisation options are only viable if surplus can be produced and sold on markets – which cannot be taken for granted. To the contrary, there are indications that, in many circumstances, farmers lack marketing opportunities and suffer from market failures and imperfections (Shiferaw, Hellin, & Muricho, 2016). Usually, higher profits are achieved from cash crops, so a certain share of these profits are, in many circumstances, needed to make agricultural mechanisation profitable for the farmer concerned and to guarantee that the initial investment can be paid back and that working costs can be covered (Hancox, 2011; Tersiguel, 1995). Access to both input and sales markets is therefore a necessary factor for anyone to drive the demand for mechanisation and guarantee its profitability.

Another factor that is important for the profitability of a mechanisation investment is the rate of utilisation. In rain-fed agriculture in SSA with only one growing cycle, the window for mechanisation use in production on one site and for one tool (such as a plough) is extremely limited – sometimes to just a few days per year – making most machinery unprofitable. This rate can be enhanced, for example, by hiring-out and sharing. Yet, machines that can only be used for time-bound and synchronic activities – that is, activities such as land preparation that need to be done within a short period of time and at the same time on all farms of a particular region – are prone to having low utilisation rates that can only marginally be improved by

hiring out, especially when hiring across isohyets or different soil types is not possible. It is thus important to enhance the diversification of machinery usage, for example by using tractors for rural transport or road construction, or by ensuring that machines can fulfil multiple purposes using different equipment parts, such as power tillers, which can be used for irrigation, land preparation, transport and processing. Machines that do not fulfil time-bound tasks, such as vehicles, processing machines or water pumps, are much more promising when it comes to higher utilisation rates (Hancox, 2011; Mrema, 2011; Pingali et al., 1987).

Creating an enabling environment for mechanisation

Mechanisation is a process that is highly dependent on – and interwoven with – the respective institutional and legal setting of a country: “Where mechanization has been successful, the role of government has in most cases been that of creating and supporting an enabling environment for private sector players to provide mechanization services especially to small-holder farmers” (Mrema, 2011, p. 25).

Technical assistance, advisory services for business operators and hiring services are essential if past mistakes are to be avoided (Mrema, 2011). All too often, mechanisation has failed due to a lack of technical skills, mechanics and engineers. Missing spare parts resulted in the “cannibalising” of machinery. In order to guarantee financial viability, entrepreneurial skills of farmers and service providers need to be strengthened. What is required, therefore, is technical training as well as business and financial training, for example through farmer field and business schools, and through increased enrolment into relevant university and vocational training programmes (AGRA, 2014; Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH [GIZ], 2014; Tersiguel, 1995).

Governments can influence the supply side of mechanisation – both for machinery and spare parts – through suitable rules and regulations on taxes and duties. However, finding the right balance can be difficult. On the one hand, the Asian experience has shown that the removal of import and sales taxes for agricultural machinery and equipment has been a key success factor for mechanisation (Hancox, 2011). On the other hand, governments will need to put in place import regulations and quality standards, which should ensure “that farmers do not waste their limited resources on equipment that ends up working for only [a] few months” (AGRA, 2014, p. 70). Also,

governments are currently facing a trade-off between agricultural and industrialisation strategies. They may want to protect some local industries (especially small and medium-sized enterprises (SMEs) producing tools and post-harvest equipment) that cannot compete with cheap imports (Höllinger, 10/2015).

An important enabling factor both for the purchase and the hiring of machinery – especially for women – is secure land and tenure rights. In some countries, land rights are a mix of formal and informal autochthon rules, of which the latter often are not recognised by commercial banks. Although farmers typically know what land rights they have, these rights might not be documented in a way that is sufficient for banks.²² Regulatory changes on this topic are highly complex and must be implemented with great care. Therefore, solutions have to be found to leverage the existing non-formalised land tenure schemes for loan securitisation without disadvantaging smaller and poorer families:

Promoting private ownership by setting up cadastres and distributing formal individual legal titles is not always the best solution, as it is expensive and may benefit elite groups that can influence formalization processes. Securing land-use rights through improved tenancy arrangements may better meet the interests of small and landless farmers, and poor rural producers. (IFAD, 2008, pp. 9–10)

Mechanisation strategies should take these success factors into account and opt for context-specific paths to mechanisation: “Priority should be given to those areas where the production potential is high, access to markets is favourable, and the provision of private-sector services from urban centres is feasible” (Shetto, 2007, p. 13).

22 However, the effect of land registration per se on access to credit in Africa should however not be not overestimated (Domeher & Abdulai, 2012).

4 Financing mechanisation – challenges and solutions

Financing mechanisation falls into the field of agricultural finance; it is, however, not a distinct conceptual category in itself. It can rather be seen as a crosscutting financing purpose for asset finance (Steinwand, 10/2015), whereas no numbers exist for the (lack of) financing for mechanisation, and very little data is available to document the amount of finance provided to the agricultural sector.²³ Data on overall credit provision in rural regions in SSA indicate a low penetration of financial services, with often less than 10 per cent of farmers having access to a loan.²⁴

One of the key bottlenecks to scaling-up mechanisation is access to finance. Adequate financial products and services are necessary to facilitate the acquisition of a machine through purchase or use, for example by hiring, leasing or contracting. Agricultural machinery or drought animals are lumpy assets that need to be financed – either upfront through available cash or savings, or by making use of a financial investment product. Depending on the cost of a machine (also relative to the income of a farmer), investment costs for the new equipment often have to be spread over several production cycles, that is, typically more than one year, and are thus also referred to as “term finance” (Höllinger, 2004). In addition, investments in mechanisation require working capital, for example for fuel, spare parts, repair or veterinary services, which may have to be mobilised through complementary financial services (i.e. credit lines, savings or payment services).

At the same time, the change in farm or farm-related activities that new machinery will induce may bring up the need for other financial products, such as insurance or more efficient money-transfer modes. Although the agricultural sector is among the most important economic sectors in most sub-Saharan African countries in terms of contribution to gross domestic product (GDP), and even more to employment, it is heavily underserved

23 No sizeable disaggregated data on the supply of fixed-asset finance in SSA are available. Available data on purpose of agricultural finance mostly lists seeds, fertilisers and paying for farm labourers (see FinScope, 2013a, 2013b, among others). Short average loan sizes in rural finance data support this assumption (Steinwand, 10/2015).

24 The several FinScope studies reveal access data for rural versus urban areas, but access to agricultural credit is often not available, as many financial institutions do not break down their own MIS data into this category. One telling dataset from Tanzania shows, however, what experts confirmed in the various interviews: the 2013 FinScope study revealed that 27.6 per cent of rural inhabitants have access to formal banking services, but only 7.1 per cent of agribusinesses are stated to have such access (FinScope, 2013b).

by the financial sector (Jessop et al., 2012; Meyer, 2015). A number of challenges on the supply side as well as on the demand side for financial services explain this, as is outlined in Sections 4.2 and 4.3 below. Overall, agricultural finance is seen as one of the major challenges in the field of inclusive financial-sector development in Africa (G20 Global Partnership for Financial Inclusion [GPII] & SME Finance Sub-Group, 2015), and this lack of access to adequate financing negatively affects the process of mechanisation in SSA (see Section 3.2).

In agricultural finance, successful concepts have been developed around input finance, for example for seeds, fertilisers and pesticides, which are seasonal investments. In contrast, financing mechanisation is much more difficult, as machines (or animals) are lumpy assets, meaning that investment costs are high in relation to the income cash flow of farmers. This is why financial products are needed to facilitate large investment amounts that can be repaid over a long period of time. The gap between income levels and investment costs is particularly high for mechanisation of food production. Food crops (as opposed to cash crops) often have a lower value – especially early in the value chain, where mechanisation tends to have the greatest effect on productivity. At the same time, the first production step (growing the food crop) typically is the riskiest part in the value chain (Ndiame, 2015). This makes it difficult to design an adequate financing product for food crop mechanisation – but at the same time, machinery financing can ease some of those problems.

As a result, various challenges come together. For farmers and other rural actors, the investment itself must be suitable for the agricultural activities and capacities, financial planning must be mastered, sufficient income needs to be generated over several years to repay the investment, and finally, the increased or new types of risk must be wisely managed. On the supply side of financial services, financial institutions must have the means in terms of liquidity, as well as the technical capacities available to provide longer-term finance. Most importantly, however, the financial products, for example the lending technology, must be highly tailored to the respective farm dynamics and income flows. This includes good agronomic knowledge that helps to gauge whether an investment is suitable – and hence profitable – for a specific farmer, and the availability of adequate risk-management tools, as outlined further in Section 4.3.

4.1 Financing mechanisation must be guided by commercial principles

One core principle propagated by financial as well as agricultural sector experts as an important precondition for viable mechanisation finance is a market orientation: a mechanisation process, that is, the purchase or use of new or additional equipment, should – apart from social and environmental aspects – be commercially viable.²⁵

Focus on sustainability: lessons from past rural finance programmes

The mechanisation of agriculture and access to finance are not new topics for rural development in SSA. For example, colonialists introduced animal traction as early as 1890 in Togo (Apetofia, 1988). In the 1960s and 1970s, governments and international donor organisations mostly intervened directly with the objective of developing both agriculture and rural areas. Back then, a focus was primarily put on the import of large tractors, made available in state-run hiring schemes, or by making use of subsidised directed-credit programmes for the agricultural sector. These rural and agricultural finance-related activities were often implemented by state-owned agricultural development banks and specialised organisations that had been created for this purpose.

Despite the large aggregate amounts of funding that were channelled through these agricultural development banks, largely disappointing results were produced on the rural and agricultural development side (Gonzalez-Vega & Graham, 1995). The strongly subsidised financial sector efforts proved to be ineffective. Many countries had introduced ratios to govern the lending of commercial banks or the agricultural development banks towards the agricultural sector. In addition, lending interest rates were kept artificially low by law, based on the assumption that small farmers could not afford high rates. Credit was seen as input to agricultural production, rather than a result of financial intermediation; and little attention was paid to a farmer's creditworthiness or loan repayment capacity, given the emphasis on disbursement and political pressure to produce quick results (Adams & von Pischke, 1992; Meyer, 2011). As a result, public as well as private financial institutions experienced high numbers of defaults. Farmers, on the other side, had to cope with debts, which were often forgiven, or simply not actively

25 This does not exclude the use of subsidies per se, but the subsidies should be used to create and enhance market-based solutions (see Meyer, 2011).

collected – resulting in a misconception of loans by mixing them up with grants. In addition, low interest rates had created a subsidy dependency of financial institutions, and operational inefficiencies were tolerated, which inhibited sound financial institutional development (Adams & von Pischke, 1992). Furthermore, the final target group of poorest farmers was often not reached, as farmers with more power used their networks to obtain loans at reduced interest rates (Nitsch, 2002). As a result, these costly interventions were not successful in reaching their objectives in Africa²⁶ (with some exceptions, e.g. in Mali): the agricultural economy did not take off and grow. Consequently, this public and donor-driven financial services provision was reduced to a bare minimum in the late 1980s.

Much analysis has been done on these past agricultural lending programmes (e.g. Adams, Graham, & von Pischke, 1984; Seibel, 2000), offering important lessons from these failures – both for the public as well as for the private sector. In retrospect, this experience of strongly subsidised credits is referred to as the “old paradigm” (Meyer, 2011). In the 1990s, with the emerging success of microfinance, a “new paradigm” started to unfold, which led to the financial systems approach. This new paradigm is based on the assumption that low-income people (including rural small-scale farmers) are able to pay interest rates, can save and have multiple financial management needs. Since then, policy approaches in both the agricultural and financial sectors have shifted towards a “commercial” or “market-oriented approach”, meaning that agricultural machines and financial services should be provided in a way that is commercially viable for the lender.

However, although the market-oriented approach can be considered successful in growing financial markets in urban and non-agricultural-related fields in many sub-Saharan African countries, the agricultural sector remains underserved. In the continued search for solutions for agricultural and rural finance, new attention is being given to agricultural development banks – albeit under the prefix of a high level of political willingness for good governance, high efficiency and financial viability. There are promising examples in SSA, where such public banks play an increasingly important role after having been reformed – for example Mali’s *Banque Nationale de*

26 However, there are successful examples of state-led agricultural development banks in Asia, which played an important role in the Asian Green Revolution. Examples are the much-cited Bank for Agriculture and Agricultural Cooperatives in Thailand and the Bank Rakyat Indonesia (Höllinger, 2011; Jessop et al., 2012).

Développement Agricole, which offers agricultural refinancing lines, or the National Microfinance Bank in Tanzania (Höllinger, 2011).

There is broad consensus in the financial systems development expert community that – for making a market-oriented financial-systems-approach work – a conducive market environment is indispensable. The state must play an active role in establishing what is often referred to as a “level playing field” for the private-market participants. This includes components such as a clear legal and regulatory framework (created by e.g. a ministry of finance), a skilled and independent supervision function (typically exercised by a central bank), as well as a market infrastructure that facilitates transparency and efficiency, and reduces systemic risks (e.g. credit bureaus, collateral registries and professional training institutes). Furthermore, the broader market environment also plays an important role, including the various aspects of doing business (e.g. ownership and insolvency regimes, requirements for opening a business), or the level of trust between economic partners and the overall economic situation of a country.

Experts agree that, especially for agricultural finance, the state and the private sector (i.e. commercially oriented financial institutions) have to play a complementary role because not all tasks and services can be provided by the private sector. There are certain types of interventions the state should undertake to increase the financial resources available for productive investment (Dafe, 2011). An example for government interventions in agricultural finance could be well-managed state-owned agricultural development banks that strive to enable market growth or inclusiveness of poor and remote population groups. An activist role of the state can also make use of (ideally temporary) subsidies to foster market growth. From a purely financial market perspective, subsidies should – in principle – not be used to directly reduce interest rates. Given the difficulties that rural markets in SSA face in many dimensions, subsidies may be deployed in a smart way, that is, to increase institutional learning, market development and market-based incentives. In many cases, subsidies help to reduce the operating costs of financial institutions that fulfil a social or development objective such as rural development, for example when refinancing lines are offered slightly below market rates (also given that often no market exists for refinancing). In their book *Financing Africa – Through the Crisis and Beyond*, Beck, Maimbo, Faye, and Triki (2011) remind us that governments should help to build up well-functioning, efficient markets, but that they should be careful not to replace them.

4.2 The demand-side of financing mechanisation

In order to understand how agricultural mechanisation can best be financed, it is crucial to understand farmers' financial management patterns and the resulting needs for financial services. This includes the entire agricultural enterprise as well as the household (on the close interwovenness of both, see Chapter 2). In order to translate the different needs into actual access to financial services, a number of constraints need to be overcome.

4.2.1 Farmers have diverse and complex financial management needs

Although this study focusses on financing options for mechanisation, financial management needs are typically not separated in the eyes of the household or business. Therefore, it is imperative to consider the financial management needs that are related to mechanisation in the context of general financial management needs. Nationally representative data from Uganda illustrates this point. If people save money, they stated in the 2013 FinScope study that they do so to meet basic needs (67 per cent), cover emergency costs (41 per cent), but also to invest in education (33 per cent) and livestock (22 per cent); similarly, people borrowed to finance education (20 per cent) and emergencies (15 per cent). If they borrowed for agriculture, financing farming inputs and farm labour were the most frequent reasons. Lastly, people insured themselves against illness or death of family members (48 per cent, 21 per cent), but also against agricultural risks such as drought (26 per cent), price fluctuations (18 per cent) and theft (15 per cent) (FinScope, 2013b).

Case Study “AccessBank”

It is possible to structure specific products that take into account a range of financial management needs, as the example of AccessBank in Tanzania, Madagascar and Zambia shows. A specific “agri-loan” was designed, which is based on detailed cash-flow projections of the business and the household, in which repayment schedules are tailored to the individual client. This makes it possible to account for irregular income flows and, hence, adapt the repayment to real repayment capacity. See Case Study 4 in Annex 2 for a detailed description.

The financial management needs differ for the five RWs.

Commercial agricultural and agribusiness enterprises (RW 1 and partly 2)

Commercial farms and SME agribusinesses generally operate in a way to maximise economic returns from the business by using professional management and accounting techniques. For these enterprises, financial management needs generally only relate to the business itself, and not the owner's or staff's private households. Commercial agricultural and SME agribusinesses have a range of business-related financial management needs, such as services for risk management, financial leverage, capital preservation and appreciation, as well as money-transfer services to pay inputs and employees (Levine, 1997).



Family-led farms of smallholders (RW 2 and 3, additionally 4)

For this group, financial management needs reflect the interwoven relationship between the household and farm. Evidence from Financial Diary research²⁷ shows that the main drivers for financial management of poor populations living and working in family-led economies are consumption smoothing, coping with risk and taking advantage of opportunities (e.g. Collins, Morduch, Rutherford, & Ruthven, 2009). A central challenge consists of building lump sums to meet larger expenditures, whether they be linked to seasonal or life-cycle dynamics, risks or opportunities. These expenditures generally cannot be met directly out of small – and often irregular and fluctuating – incomes, which often barely cover the basic needs and current consumption levels (Rutherford, 2001). Furthermore, this group needs financial transfers to send and receive money,



27 The use of Financial Diaries is a recent research approach in which trained local researchers visit a set of households fortnightly during a year in order to record and reconstruct, as detailed as possible, all kinds of money management transactions along with the related value, the kinds of services or devices used, their financial partners and their purpose. Thus, the money management behaviour of the participating households can be chronicled.

for instance to care for family members living in the next town or to receive remittances from family members. Commercial integration into value chains differs widely within this category. Accordingly, family-led farms of smallholders may have more household- or more farm-related financial management needs.²⁸

The following table shows some financial management needs in family-led farms of smallholders.

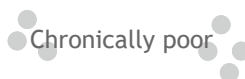
Table 5: Financial management needs of family-led farms		
	Household	Farm
Consumption smoothing	<ul style="list-style-type: none"> • Meeting regular expenses from irregular income • Financing foreseeable / programmed expenses related to life-cycle events 	<ul style="list-style-type: none"> • Meeting production cost of crops, covering seasonality of agriculture for related expenditures and incomes
Risk mitigation	<ul style="list-style-type: none"> • Responding to emergencies, illnesses and other sudden requirements for money 	<ul style="list-style-type: none"> • Responding to crop loss, loss of machinery, illness of workforce / farmer, etc.
Taking advantage of opportunities	<ul style="list-style-type: none"> • Migration/ financing somebody's migration from the household • Making investments or large purchases related to improved housing, consumer durables and others 	<ul style="list-style-type: none"> • Making investments or large purchases related to income-generating assets; invest in farm power, inputs, market access and relationships • Move into non-agricultural economic activities
Financial-transfer options	<ul style="list-style-type: none"> • Bridge distances and save time: get and send money to and from relatives, pay for certain services / products 	<ul style="list-style-type: none"> • Bridge distances and save time: pay input providers and receive payments from off-takers
Source: joyn-coop (n.d.), with information from Christen and Anderson (2013); D. Collins et al. (2009)		

28 For a more detailed overview of financial management needs and relevant products for smallholder groups with different degrees of commercialisation, see Christen and Anderson (2013, Tables 2–4). The findings are based on the first results of their financial diaries with smallholders.

To capture all financial needs related to mechanisation, another important group to consider are the actors along the machinery supply chain: these can be SMEs, such as machinery dealers, producers or traders of spare parts or repair-service providers, repair shops and local manufacturers. These SMEs will also require term finance products, short-term finance and insurance products. Depending on their financial strength, these actors could also act as providers of finance for their clients in a typical intra-value chain finance setting (see Section 4.3.4.).

The chronically poor of Rural World 5

This rural population group needs the household-related financial services of the family-led farms/ households described above, but most likely it strongly depends on financial services that facilitate external support – including money-transfer services to receive money from relatives and financial transfers (social protection systems or conditional and unconditional cash transfers, for instance in the form of graduation programmes).

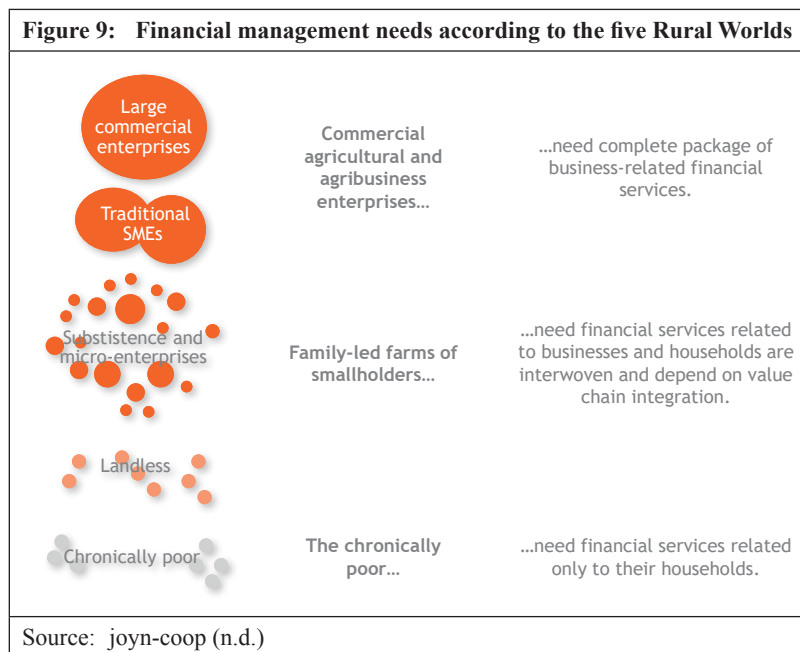


Case Study “Graduation Programme”

There are various donor-led programmes whereby the target group receives small productive assets in combination with training and consumption support. Graduation programmes are one example for such an approach, as has been demonstrated by Fundación Capital. See Case Study 5 in Annex 2 for a detailed description.

Financial management needs are much more often met through informal services. Also, households and family-led enterprises use interrelated combinations – from informal, semi-formal and formal providers or schemes – to address all of these financial management needs. Furthermore, financing needs may be managed directly within the household or the farm. For instance, life-cycle events such as birth or care of elderly and children are often “covered” through intra-family coping mechanisms based on implicit inter-generational contracts (Zattler, 1997), for example grandparents taking care of their grandchildren.

Figure 9 summarises the financial management needs of the five RWs.



The specific mechanisation-related financial needs or patterns are always embedded into the financial and economic realities of the respective household or farm. They can constitute working capital needs, for instance for financing tractor services or costs of own animals or machinery; asset finance needs for acquiring a machine, animals and equipment; or risk-management services that help farmers to deal with increased or different risks (see Chapter 2). Many small-scale financial management needs can be met through generic household or business financial services. Long-term qualitative research (financial diaries) shows, however, that there exist a number of conditions when specific financial tools or techniques tailored to agriculture are needed. Households may run into extreme cyclical liquidity management problems if their main income source is farming – a business that is governed by high seasonality. Production may be relatively risky, for instance, due to weather sensitivity of crops or due to price volatility. Production may also fail due to catastrophic events but must still be resumed the following season (Christen & Anderson, 2013).

Finally, mechanisation-related financial management needs depend on the form and intensity of mechanisation and its cost, as it relates to farm income and assets. The (relative) cost of hiring and ownership are key variables for determining the profitability and preference of different mechanisation options. For the agricultural expert community, the affordability of machines by smallholders constitutes an important concern (Neubert, 10/2015; Singh, 11/2015; Sims, 12/2015). Furthermore, the labour capacity of a machine and the amount of available land or processing material need to match. Many parts of SSA are characterised by small average farms, which is why the labour capacity of medium- and high-intensity machinery exceeds the land available to a household in most cases. As a result, investment in a higher-intensity machine can and should only be undertaken if a model of co-ownership of a machine (machine-sharing), or co-usage under a service contract model is possible. For such co-ownership and co-usage, relevant financial services should be made available, that is, to finance the cost of partial *ownership*, or to transfer money to pay for or earn from machinery *use*. Actual individual machine investments and related term investments are thus only relevant for a few farmers or intermediaries who are better placed to opt for high- and medium-intensity mechanisation that typically is also capital-intense. Low-intensity mechanisation options might be relevant for a larger number of farmers, but this can often be met with short-term and less specialised financial products, that is, in the context of microfinance.

It is important to note that financial services needs differ according to gender. Gender may influence access to certain financial products, and the use of financial instruments may change economic and power relationships between men and women. Mayoux (2000), for instance, points to the fact that a woman receiving a loan cannot necessarily decide on its usage. If a woman increases her income, it is likely to be used to cover household- (and not business-) related costs.

4.2.2 Constraints of farmers in accessing financial services for mechanisation

A wide range of constraints prohibit the above-listed financial management needs from translating into access to financial services, depending on the target group or RW being looked at (Doran, McFadyen, & Vogel, 2009; Jessop et al., 2012; Meyer, 2015). Constraints exist on

two levels. On the first level, very basic constraints prevent a need for financial intermediation from being translated into an effective demand, that is, that the particular need is openly expressed as a demand on a financial intermediary. On the second level, a number of constraints inhibit a translation of effective (i.e. expressed) demand into successful access to financial service provision.

A first-level limitation that particularly applies to smallholders is the low level of business literacy, often paired with little financial literacy. This may hinder a person from transforming a clearly existing financial need into a demand. A survey by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) Uganda uncovered one such instance. It found that smallholder farmers did not make use of available micro loans to pre-finance their harvest incomes, but instead sold them to traders directly off the field. Farmers did so because they believed that micro loans were too expensive. Farmers accepted a 40 to 60 per cent loss of margin, assuming that prices would have most probably been higher had they waited a few months to sell their harvest (Steinwand, 09/2015).

Another first-level constraint is low productivity levels and, hence, low financial margins experienced by the majority of farmers in SSA, especially those from RWs 3 and 2. These low margins are combined with highly variable cash flows over the year (Doran et al., 2009). The wise usage (and adapted provision) of financial services is hence difficult, especially with regard to larger investments such as machinery.

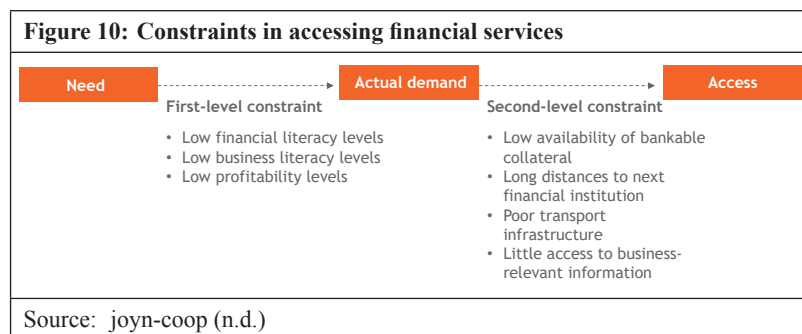
A typical second-level constraint, which often inhibits a need from being translated into access, is the availability of “bankable” collateral, that is, assets that a financial institution can foreclose in case of a loan default to mitigate its loss. This is a constraint faced by representatives of all RWs except most of RW 1. Typical bankable collateral items are formal ownership titles on land or on real estate. In many sub-Saharan African countries, land ownership is not formalised, not clear or guided by complex autochthon land rights systems, which often do not follow an understanding of individual land ownership. As a result, typical means to secure a loan are not available. This especially applies for women: due to patriarchal cultural heritage rules, women in most SSA countries do not – or only to a very limited extent – inherit family land and house ownership. Consequently, the likelihood of a woman possessing or being able to pledge bankable assets is very low. This is often cited as the main

reason why women have less access to finance (G20 GPFI & SME Finance Sub-Group, 2015). In the absence of bankable collateral, alternative types of collateral such as personal guarantees or joint liability groups play an important and often powerful role. These types of personal guarantees are mostly suitable for small loan amounts but are not enough to secure term investments.

The performance risk of agricultural production is another important second-level constraint to farmers and agro-entrepreneurs of RWs 2 to 4. Production is sensitive to external factors such as weather and diseases, and harvest is sensitive to suitable storage and transport facilities that prevent post-harvest losses. This creates specifically strong needs for financial intermediation, that is, for suitable insurance products to mitigate performance risks. But exactly because of the high-risk nature, and because it is costly to serve a large number of small farmers in remote areas, suitable products are not available (see Section 4.3.2 on insurance).

In addition, long distances to the next outlet of a financial institution – paired with restricted mobility and poor transport infrastructure in many regions of SSA – make it time-consuming and costly to interact with a financial institution, even if a concrete demand for financial intermediation exists. The same applies for participation in, for example, producer associations, which facilitate farmers’ access to relevant markets, knowledge and information (Initiative for Smallholder Finance, 2013b).

Figure 10 summarises the constraints on access to finance.



4.2.3 Alternative business models for individual ownership of machinery exist

Individual or private ownership of farm equipment and machinery brings huge benefits in terms of timeliness of field operations and clarifies responsibilities for maintenance and energy supply. Yet, in SSA, for medium- to high-intensity machines, this ownership model is economically viable almost exclusively for bigger farmers in RWs 1 and 2 (Sims & Kienzle, 2009). Against the background of small average farm sizes in SSA, private ownership is not suitable for many farmers. Offering a range of alternative models for individual ownership is relevant for scaling-up mechanisation.

Private owners might increase the profitability of their investment by offering hire services to other agricultural households, or by diversifying machinery use for off-farm usage. In industrialised countries with a high degree of mechanisation, experience shows that **cooperative systems** have been crucial in scaling-up mechanisation (Breuer et al., 2015). Farmer groups can pool resources and have better access to credit and development programmes to acquire machinery that would otherwise not be accessible to them. Farmer groups are common in SSA, but machinery rings and cooperative systems are less so.

Case Study “CUMA Benin”

A case example from Benin shows a cooperative that was specifically set up to buy agricultural machinery for its members, who can use the available machines and receive training. See Case Study 6 in Annex 2 for a detailed description.

Joint-ownership schemes seem very appealing in theory but often face severe governance and organisational problems when put into practice: elite capture is common in SSA. In addition, in the context of shortened rainfall periods, crop operations can be undertaken within a limited time-span only, resulting in competition for the available machines and yield-reducing delays for farmers within the cooperative (AGRA, 2014; Kienzle & Sims, 2006; Neubert et al., 2011).

Increasingly common in SSA are **outgrower schemes** and **contract farming**, in which agriculture is carried out based on an agreement between a producer and an off-taker that is concluded prior to production. Such schemes can be useful distribution channels for mechanisation. Often,

the off-taker or bigger farmers working within the scheme will purchase mechanisation tools – mainly tractors or draught animals with ploughing equipment – and offer their services to the scheme’s smaller outgrowers, generally deducting the costs from payments for delivered harvests. Small farmers may furthermore profit from access to inputs, credit and marketing services provided by the contractor, as well as price-risk mitigation through favourable terms and buying agreements (OECD, 2006; World Bank, 2009). Yet, terms and conditions of these schemes have to be thoroughly scrutinised, because “in their worst form [...], contract farming deserves its reputation of turning producers into wage labourers on their own land” (OECD, 2006, p. 59).

Case Study “NWK Agri-Services”

A successful example for contract farming exists in Zambia, where a large agricultural company named NWK works with more than 10,000 small and medium-sized farmers seeking to create a win-win situation. NWK pre-selects farmers on defined criteria such as size of landholdings, and facilitates access to finance from banks and provides training on machine use. In return, all farm output needs to be sold to NWK and NWK can realise economies of scale in further processing. See Case Study 7 in Annex 2 for a detailed description.

A model that has proved very successful in Asia – and that is gaining importance in SSA too, according to the expert community – is mechanisation by **service providers**, that is, a model of co-usage of machines through hiring. These service providers are either wealthier farmers (in RWs 1 or 2) or specialised operators who own one or more equipment parts (usually medium-intensity machines such as smaller tractors, power tillers and irrigation pumps), and hire them out to smaller farmers. Payment can be made in cash and often in-kind, and some service providers even allow their customers to pay at harvest time. This model requires neither a large capital investment nor fixed operating costs from smaller farmers, and it is therefore often the most feasible option for farmers in RWs 3 and 4 (and sometimes 2), for whom individual ownership is not economically viable (Baudron et al., 2015; Sims & Kienzle, 2009; Sims et al., 2011). Nevertheless, access to suitable financing products for the service providers (and for the hiring farmer if payment is instantaneous) is still necessary and is therefore important to increase access to productive machinery for small-scale farmers.

For RW 4 – and partly RW 5 – the **grant model** is practiced in donor, government or non-governmental organisation (NGO) programmes. Small equipment is provided through grants to poor farmers, with the aim of providing a basis for economic growth, for example small hand tools or pumps (see Case Study 3 “Pedal Pump” and Case Study 5 “Graduation Programme” in Annex 2). Financial services in this case, if any, typically are needed in the form of money-transfer or saving services, as grant or graduation models often are accompanied with an initial savings amount that the target group receives, for example on an account as a basis for further savings.

4.3 The supply side of financial services for mechanisation

On average, access to finance (defined as access to formal bank accounts) in SSA has shown a significant increase over the last decade, and even grew from 24 per cent in 2011 to 34 per cent in 2015 (World Bank, 2015b). Some countries have shown impressive achievements: in Kenya, financial access increased from 27 to 67 per cent in just seven years, from 2006 to 2013 (McKay, n.d.). This was mostly driven by a strong increase in urban-based financial services and through the strongly increased outreach to rural areas via the use of mobile devices. Access to finance for agriculture, however, has hardly shown any sizeable improvements so far (Jessop et al., 2012).

Table 6 provides an overview of access to agricultural credit data from selected countries in SSA.

Country	Agriculture in GDP	Employment in agriculture/total employment	Rural population	Domestic credit as % of GDP	Agricultural credit/total bank credit
Ghana	34%	56%	49%	31.3%	6%
Kenya	22%	75%	28%	42.2%	5%
Mali	45%	80%	64%	n.a.	15%
Senegal	15%	78%	58%	n.a.	3%
Tanzania	42%	80%	74%	18%	10%
Zambia	20%	85%	64%	22.4%	19%

Source: joyn-coop (n.d.), based on Jessop et al. (2012)

Jessop et al. show that the percentage of agricultural loan portfolio on the total bank portfolio in several sub-Saharan African countries is very small – if compared to the role of the agricultural sector in terms of contribution to GDP and in terms of employed adults (Jessop et al., 2012). It must be noted that these numbers also include large loans for farmers of RW 1; hence, financing for smaller farmers can be assumed to be at a significantly lower level.

With a new wave of acknowledgement of the high relevance of growing agricultural finance during the last 10 years,²⁹ a range of important innovations in the field were brought forth. Yet, these have so far mostly focussed on low-cost but widely needed agricultural production input factors such as seeds, fertiliser and pesticides. Many schemes have shown very promising results in terms of increasing access to finance such as value chain finance. Financing of larger assets, however, such as machines and expensive farm, storage, processing and transport equipment, still remains a major and recognised challenge.

4.3.1 Supply-side challenges to provide financing for mechanisation

Financial service providers face a range of constraints when serving the agricultural sector in SSA. Agricultural finance practitioners state that the most important constraint is the high cost of servicing the rural and agricultural sector (Kortenbusch, 10/2015). These high costs occur from a combination of factors: long distances to clients, low population densities, communication challenges, for example given the great language diversity in many sub-Saharan African countries. Furthermore, it takes a large upfront investment by a financial institution to build up a reasonable level of knowledge on agricultural production, value chains and markets in order to design products adequately.

Risks associated with the agricultural sector are the second most important constraint. Agriculture itself is a risky and complex sector: performance depends on a variety of input factors including soil and seed quality as well as agronomic knowledge and the availability of suitable tools and equipment

29 This has been documented through a series of high-level international conferences, including from the Making Finance Work for Africa Partnership, the “Cracking the Nut” conference series and the attention given to the topic at the G20 level.

for production, storage, processing and transport. External factors such as weather conditions have a great influence on the production outcome (conducive weather and calamities such as droughts), and food crops especially are sensitive to outside conditions, for example temperature. Furthermore, there is price risk: agricultural commodity markets can be subject to strong price variations on the global as well as regional levels. Finally, the ability of a farmer to manage a new investment adequately and integrate it into the farm is a risk to the financial institution and must be part of the client assessment. Some of those risks can be managed with increased technical knowledge and experience of staff, and others can be mitigated with dedicated financial instruments such as insurance.

According to agricultural credit experts (Kortenbusch 10/2015, Höllinger 10/2015), a related aspect is an exaggerated *perception* of risk by supply-side actors. Financial institutions often do not fully understand agricultural production and agriculture-related business functions, which is why they flag the sector as highly risky and keep out of it. Different agricultural finance projects have shown that once financial institutions understand the inherent risks of the sector, they are able to manage those to some extent and service this client segment.³⁰ The need to have a good understanding of agricultural production is very relevant for financing mechanisation, since the suitability and impact of a respective machine on the entire farm business has to be anticipated.

An important further challenge is access to long-term funding, that is, term deposits, bonds or refinance loans. This is a constraint that locally based financial service providers are more likely to face than commercial banks. Due to the seasonal and often covariant nature of farming and other related businesses in rural areas, all farmers in a certain agro-ecological zone experience similar cash cycles: at the beginning of the planting season, funds to purchase seeds and fertilisers are needed, whereas excess of finance is often available at the end of the harvest. Furthermore, long gestation periods in agriculture (e.g. in the case of tree crops) often require payment-free periods (grace periods). The collected savings in rural areas (which not all financial institutions are allowed to) are characterised by small and short-

30 In partnership with Opportunity Bank, GIZ Uganda has provided support for in-depth market research on different value chains. Based on this knowledge, the financial institution has developed tailored products and is now serving the value chains with great success (GIZ, 2013; Steinwand, 10/2015). See also Case Study 4, “AccessBank” in Annex 2.

term amounts. All this results in a mismatch between the availability and the term of liquidity, which is referred to as “maturity mismatch”. Savings are usually not sufficient to finance loan payouts, as a financial institution is not allowed to use short-term liabilities (savings) to finance long-term assets (loans).

But with the size of financial institutions decreasing, tapping into affordable external refinancing (e.g. from local or international investors) is becoming more and more difficult. This is partly due to decreasing levels of formality and often also decreasing levels of financial stability. Since investments into machinery require higher loan amounts and long maturities of up to five years or more, access to long-term refinancing becomes particularly important.

The weak institutional capacity of financial service providers is repeatedly stated as a major challenge in general agricultural finance. Although basic banking capacities across SSA have greatly improved over the last two decades, there is still a high need to foster basic banking skills, especially with regard to risk management. Examples are the development of risk models, which predict the probability of default within a loan portfolio, and the internal precautions that a financial institution has to take accordingly (e.g. to put a certain percentage of risk-rated loans aside to build up a financial buffer in case of loan default).

Furthermore, and very importantly, most financial institutions lack insights, experience and hence sectoral knowledge of the agricultural sector. Barriers to building up such knowledge are the high upfront costs in staff capacity and agricultural client-analysis standards (Steinwand, 10/2015). Consequently, client-analysis techniques, risk models and product designs are not adapted, which is a reason why banks avoid agricultural lending. Additionally, many financial institutions have little knowledge of – and lack the processes for – product development and adaptation. Unlike top-down approaches to product design, financial service providers can profit by learning directly from their customers so that product features can address needs, constraints and capacities of their clients (Mattern & Tarazi, 2015).

Case Study “Kafo Jiginew”

Kafo Jiginew is a credit cooperative in Mali that provides a very good example of a highly adapted machinery loan. See Case Study 10 in Annex 2 for a detailed description.

Finally – and this strongly applies to financing mechanisation – there is the risk from subsidised agricultural promotion programmes of governments (e.g. the purchase of equipment or input factors), which may lead to a crowding out from the commercial banking sector. High population growth – paired with continued urban migration – puts governments increasingly under pressure to show visible steps that improve food security. This dynamic might very well lead to increasing levels of government intervention and the continuous hesitation of banks to enter into agricultural finance.

4.3.2 Various financial products can enable mechanisation

The transformation that mechanisation brings to agricultural enterprises or households should be accompanied by a wider range of financial products and services next to loans (or leasing) to facilitate the best possible economic adaptation to that change. An example is the combination of an investment loan with a credit line to account for the increase in working capital costs due to a new machine and to ensure that a borrower can meet all related financial obligations.

Depending on the type of RW and the intensity of mechanisation (i.e. hand tools or large machinery), different financial products – or combinations of products – are better suited to enhance mechanisation. The identification and promotion of the most suitable financial product also strongly depends on the situation of a farmer: for example, what is the situation in view of land ownership, ownership of other (moveable and immoveable) assets, access to markets, knowledge and skills related to using the new machinery, credit history and the level of financial capability?

The main product categories relevant for mechanisation are: commercial loans (including credit lines), promotional loans, leasing, savings, insurance and money-transfer products. Some of these products can be promoted with “smart subsidy” components, such as guarantees or, partly, redemption payments for loans (*Tilgungszuschuss*). For very poor target groups, transfer payments can be combined with micro loans in matched grant schemes. We elaborate on these different products below.

The question of what constitutes a suitable financial product needs to take into consideration how – and by whom – the machine will be used. A very different set of financial products is needed for acquiring a machine as an owner, for co-ownership or for use only (see Section 4.2.3).

Case Study “Hello Tractor”

An innovative example for the service-provider model (shared use, single ownership) is “Hello Tractor”, a young Nigerian start-up enterprise that buys tractors and hires them out via an SMS-based hiring and payment scheme. See Case Study 8 in Annex 2 for a detailed description.

In the following sections, different types of financial products that enable mechanisation are described in detail.

Investment loans

Loans are the most important instrument to finance an investment in agricultural machinery. They are most effective if they adequately take into account the affordability of a machine vis-à-vis the income level of a farmer. Very small loans (i.e. micro loans with a maximum duration of one year) for affordable, simple hand tools (e.g. a planting stick or hand pump), as well as very large loans, such as for a processing machine for large agricultural companies, are relatively easy to implement.

For small amounts, microfinance provides the suitable technology: micro loans are small³¹ and of short tenure, and can be provided against alternative collateral such as guarantors and movable assets. Large loans, for example for warehouses or expensive machinery, are typically limited to well-established agro-businesses. These businesses often comprise international clients of commercial banks who can provide sufficient guarantees and are well-capitalised.

The challenge lies with medium-term loans (1–5 years), which are needed by SMEs of RWs 2 and 3. Such medium-term loans (together with leasing products) are the core financial products needed to foster mechanisation. The lack of adequate financing products for SMEs is a phenomenon that is not limited to the agricultural sector, but a common one for SMEs across the world – often referred to as the “missing middle” (Doran et al., 2009). These enterprises typically lack traditional bank collateral (i.e. bankable land or other fixed-asset titles) to secure a larger investment, or they are not able to present standard accounting figures to document their financial situation.

31 Micro loans in SSA are not more than a few hundred euros. In its 2014 Annual Report, the microfinance investment fund REGMIFA, which is active in 17 countries in SSA, reports an average loan amount to microfinance borrowers of US\$ 600 (SYMBIOTICS, 2015).

There are several options and methods to solve the problem of collateral. The most popular one is the use of what is called “alternative collateral”, that is, another form of putting pressure on the creditor in order to reduce his or her moral hazard.³² The two most widespread forms of alternative collateral are “contract-based securities” and security created through “joint liability groups”.

Contract-based securities

Financial service providers can accept a contract between two representatives of a value chain as security. Typical examples of contract-based securities are warehouse receipts: lenders provide a loan to clients if they bring receipts from a trusted and recognised storage facility (Miller & Jones, 2010). Such schemes can help to circumvent a lack of land titles. External value chain finance schemes such as these have been set up successfully, for instance by the Potato Initiative Africa. However, setting them up is a complex and often lengthy undertaking, as much trust has to be built up between several parties. Furthermore, using the model for mechanisation has limitations, as the amount of collateral that a farmer can secure is limited and is typically only valid for one season. Furthermore, farmers require time and effort to establish a contract in order to build up trust. Lastly, contract enforcement challenges due to weak legal framework conditions often impede contract-based collateral. Therefore, contract-based loan securitisation (only) works for smaller machinery (e.g. hand tools), where the related financial risks are comparatively small.

Joint liability groups

Joint liability groups are typically created through groups in which members accept to take over loan repayment responsibility for one group member, for example. However, group-based liability can also be created in other ways. Membership-based organisations such as producer cooperatives can, for instance, accept to act as guarantor for one of its members. The amount secured varies according to the type and size of the group. Typically, however, this mechanism can only be used for small loans. Since

32 Moral hazard is caused by information asymmetry between a financial institution and its borrowing client. It is the risk that a party has not entered into the contract in good faith or has provided misleading information about its assets, liabilities or credit capacity, or has an incentive to take unusual risks in a desperate attempt to earn a profit before the contract settles (Erlei & Szczutkowski, n.d.).

women often have less access to documented wealth (e.g. land titles, or even moveable collateral), joint liability models are an option for increasing women's access to small loans.

Both types of loan guarantees can be combined with general loan characteristics, which make mechanisation loans more suitable for small farmers. These characteristics include extending loan maturities to keep payment rates low, accepting less frequent and flexible payments, allowing grace periods in which repayment can be paused, and bullet repayments, whereby the whole loan amount is repaid all at once (all without increasing loan costs). In addition to investments that will bring a change to the input-output structure of a farm, it is advisable to provide an additional credit line so that – depending on the type of machine – operational costs such as fuel costs can be paid within an available extra-flexible loan budget.

Leasing

Leasing means that the owner of an asset (lessor) lets it to another person (lessee) to use for a certain time against regular payments (Miller & Jones, 2010). The key characteristic of leasing is the separation of ownership of the asset from its economic use. This way, the leased asset can serve as security for the financing contract – and thus helps to reduce the need for collateral. Leasing is particularly useful as a financial instrument for small businesses, as they often lack a credit history, transparent financial accounting and/or sufficient collateral to access traditional forms of financing. Leasing is therefore particularly suitable for the financing of agricultural mechanisation (Höllinger, 2004).

Great hope has been put into different micro-leasing schemes (e.g. in Uganda, a pilot oxen-leasing product was developed by Centenary Bank and the Tanzanian micro-lease company Selfina) to offer innovative ways to improve farmers' access to finance for equipment. So far, unfortunately, not much scale has been achieved with the different products that have been developed. Reasons for this are as straightforward to explain as they are difficult to solve. Most of all, the concept of leasing is new to most sub-Saharan African markets, meaning that much awareness- and capacity-building are needed. With the exceptions of Nigeria and South Africa, the leasing market is in its nascent stage in most sub-Saharan African countries. Penetration rates range from 1 to 5 per cent – compared to a global average of 20 per cent (Making Finance Work for Africa, 2016). The

largest bottlenecks are the unfavourable general operating environments for leasing: in most countries, value-added tax (VAT) needs to be paid each time a product changes ownership. This makes leasing very expensive, as the lessor and the lessee need to pay taxes twice: first when the lessor purchases the object, and again once the lessee has completed the lease purchase. Ideally (as in Germany, e.g.), VAT is only paid once, often partly or fully covered by the lessee. But if VAT is applied two times, leasing fees become very high and are therefore only attractive for highly profitable businesses – which is often not the case for small-scale agriculture. Furthermore, legal regimes often do not differentiate between ownership and possession – this can make repossession difficult for the lessor in cases of payment default. In some countries, lengthy legal procedures are necessary to seize a leased asset, which makes the process expensive and cumbersome for the lessor. Additionally, a secondary market for the leased objects has to exist to make repossessions profitable for the leasing company. The bigger and better-developed the secondary market of the leased assets is, the easier and more efficient it will be to sell them and recover their value. Since the leased asset functions as collateral, it is in the interest of the lessor to closely monitoring the machine to ensure correct use and maintenance – which comes at high costs. Whereas tracking systems (e.g. GPS and automated machinery data) are built into large machines nowadays, which makes tracking simple, this is not the case for smaller equipment. It is thus typical for a leasing officer to undertake on-site visits, which are costly and time-consuming. The more remote the area that the leased machine is used in, the more likely that monitoring and repossession become a challenge (Höllinger, 2004).

Leasing also becomes more attractive from a financial institution's point of view if the machinery supply chain is already well-developed, that is, when chains of importers, manufacturers, retail dealers and repair shops, etc., exist. This reduces the risk of technical failures and high-value depreciation, and it promotes a healthy secondary marketplace and overall market standards that make it easier to design, price and, hence, scale leasing products (Höllinger, 2004). Similar to loan products, agricultural machinery leasing-products should be adapted to the business case of the respective machine, that is, taking the cash flow that the machine can generate into account, and knowing its seasonality.

The International Finance Corporation (IFC), under its Africa Leasing Facility, is working on establishing or adapting legal and regulatory frameworks for leasing in several sub-Saharan African countries. However,

this process has only started recently, and leasing markets are likely to take time until they mature and allow for efficient leasing activities. Agricultural leasing also bears the inherent risks of portfolio concentration and covariant risks, and the requirement for leasing company personnel to have agronomic knowledge. Even under conducive framework conditions, leasing products can be comparatively expensive for borrowers (lessees), because leasing contracts tend to be shorter than the amortisation time of an asset to ensure an adequate repossession value to the lessee – this makes the lease instalments high. In addition, leasing contracts are often (compulsory) combined with insurance contracts. Moreover, upfront payments (or compulsory savings) of up to 25 per cent of the asset value are often required to cover the strong devaluation in the early life-cycle of an asset. Consequently, leasing is more suitable the more profitable a machine investment is. Much work remains to be done on enhancing framework conditions and developing suitable agricultural equipment leasing-products.

Case Study “DFCU Leasing”

Only very few cases show how agricultural leasing products can work. The leasing company DFCU Uganda offers leasing products that are also geared towards the agricultural sector – but the product is expensive and the market remains a niche. See Case Study 9 in Annex 2 for a detailed description.

Insurance products

Insurance is one among several instruments necessary for risk management in the agricultural sector. Well-designed agricultural insurance products can contribute to leverage effects in production and income, as they can specifically help manage the risk that stems from specialisation and other (non)agricultural risks (Höllinger, 2011, p. 34). In SSA, the availability of agricultural insurance is low: out of all the people active in agriculture, on average only 2–5 per cent are said to engage in agricultural insurance, with the exception of a few countries with higher rates (Demirguc-Kunt, Klapper, Singer, & Van Oudheusden, 2015). For mechanisation specifically, asset insurance products can play an important role. Such insurances cover risks of damage or theft, for instance. However, they only make economic sense for medium- to high-intensity mechanisation and are, hence, mostly applicable to farmers in RWs 1 and 2 who purchase and own large machinery.

Apart from insuring the asset (i.e. the machine) itself, it is much more important to reduce the risks that are generally associated with agricultural production itself, as those may have a much more severe effect on farm profitability. Insuring these risks, in turn, can improve the risk-bearing capacity and the willingness of farmers to invest. Farms' main risks can be distinguished into two types: performance risk and price risk, for which insurance products exist. Performance risks negatively influence the results of a production or processing process. An example is the risk of unfavourable weather conditions that result in a meagre harvest. Price risks are risks of strong price fluctuations, which can result in a reduction or loss of income when selling the products in the market. This applies for local markets but also affects globally traded goods (typically cash crops such as cotton, tea and coffee). Agricultural prices fluctuate seasonally on a regional level due to supply and demand dynamics in the markets, which are usually not perfectly integrated nationally and with world markets (e.g. Baltzer, 2014). However, although negative co-variance between local production and price may reduce the income risk on average, this is not a sufficient means of income stabilisation for individual farmers (Brown & Kshirsagar, 2015). On an aggregated level, covariant risks exist.

Typical performance-risk insurances are weather (index) insurance, area yield insurance and livestock (mortality) insurance. Price management instruments such as forward contracts exist to guard against price risks³³ (G20 GPMI & SME Finance Sub-Group, 2015). In the last 10 years, donors have been paying much attention to the development of agricultural index-based insurance schemes such as weather index insurance. Index insurance products define a certain event (index) that statistically coincides with a certain peril. For example, a certain amount (or lack) of rainfall will damage a crop. Farmers who cultivate a certain crop and buy the insurance product will automatically receive a payout once rainfall falls below this pre-defined rainfall threshold in a defined area. This way, the index helps to reduce the risks of moral hazard and adverse selection³⁴ of (self-) reported yield

33 Forward contracts is a financial instrument in which a seller and a buyer of a product agree on a defined price that will be paid at a defined date in the future. This is helpful in trading goods with highly fluctuating prices and provides predictability for both trading parties (for the seller on the price, for the buyer on the amount).

34 Adverse selection in the context of insurance means that there is a risk that clients who know they face high risks buy insurance, whereas clients with little risk do not invest in an insurance policy. Consequently, the insurer will build up a portfolio that has a high risk-bias, which, in turn, drives up the price of the insurance.

insurance schemes. Additionally, it becomes cost-efficient once the index is developed³⁵ (World Bank, 2011b). Insurance indexes can be of benefit for financing mechanisation, whereby in the case of a draught, for example, an automatic payout covers (part of) the expected loss of a farmer. The money that is paid out could potentially be used to (partly) service loan instalments, and hence prevent a loan client from defaulting – but this would require an adequate costing model of the insurance, which is often difficult to implement. Important progress has been made in reducing transaction costs for insurance providers by combining index insurance schemes with mobile financial payments: such bundling makes much sense and is a concept that could positively contribute to sustainable mechanisation (G20 GPFI & SME Finance Sub-Group, 2015).

Especially for family-led farms, access to suitable and needs-based standard (micro) insurance products can play an important role, as they are associated with the performance risk to the health and fitness of a farmer, for example. In case of illness / injury, no or less work can be performed, which may occur at a critical time of the year, resulting in high emergency costs and reduced income. This, in turn, may negatively affect repayment capacity, for example for an outstanding mechanisation loan. The most widespread insurance product is credit life insurance, which protects the relatives of a loan client from having to pay the outstanding principal of a loan in case of the sudden death of the borrower (Meyer, 2015). An employment scheme can also act as insurance (Gehrke, 2014).

Agricultural weather insurance is highly relevant for food security, especially for subsistence farmers. In cases where harvests are destroyed or significantly reduced, insurance payments can provide the financial means to buy the food that could not be produced on the market. However, weather insurance products are hardly available at scale due to numerous challenges in product design, but also due to high costs, free rider problems, information asymmetries and a lack of awareness (WFP & IFAD, 2011).

35 The actual challenge in index-based insurance lies in the design: based on a combination of gestation weather data, the right point for payout must be defined. Both existing weather data to calculate a statistical probability of a certain weather constellation occurring, and the infrastructure to objectively measure weather events in a defined area are often not available and require (public) investments.

Savings products

Saving means setting aside liquidity resources for expected or unexpected future expenses. For agricultural mechanisation, generating savings can fulfil several important functions. First, savings can make an investment in a new machine possible. Savings can be generated from farm and non-farm income, depending on whether one or another source is more important. Seasonality of agricultural incomes and expenditures can be eased by using non-farm income, thus off-farm activities can help finance agriculture. Also, the opposite scenario – agriculture income is drained for non-farm activities – is found (Reardon, Crawford, & Kelly, 1994; Mathenge, Smale, & Tschirley, 2015) – most likely depending on opportunities – illustrating the complex linkages between farms and households. No systematic relation between the level of income (RW) and the share of off-farm income is found. The NGO “MyAgro” (see Case Study 1 in Annex 2) provides a good example of how targeted saving schemes can enable a farmer to set aside savings for a defined future investment.

Secondly, savings can be used as a risk-management tool and a financial buffer. For example, savings can provide immediate (and cheap) liquidity in cases where farming equipment needs to be maintained or repaired. Savings can be put aside so as to be financially prepared to pay for hiring agricultural machinery, or to pay costs related to machinery service providers, for example tractor labour (see Case Study 8 “Hello Tractor” in Annex 2).

Savings also fulfil an important function for consumption smoothing, especially in family-led agro-businesses. Against the background of complex income sources, savings can be a highly effective tool to even-out financial inflow and outflow streams over the year.

Increasingly, savings are considered a suitable financial instrument for lower-income or smaller farm enterprises. The more economically vulnerable a target group, the more that caution should be applied for the use of loans, as they bear the risk of indebtedness if not well-adapted to the needs and financial capacities of its receiver. Savings, however, have their limits regarding the current income possibilities of a person, a household or an enterprise, and are therefore not always suitable for larger investments. But for the purchase of small machines and agricultural equipment, savings provide a low-risk and low-cost financial product.

Matching grants

To support the mechanisation of agricultural-related activities in the very low-income segment (RWs 4 and 5), matching grants can be used by donors and government (Hamp, 10/2015). Matching grants are defined as non-reimbursable transfers, either in monetary or in-kind form, for a particular purpose and provided under certain conditions. Such matching grants can (but do not have to be) combined with financial products, for example a micro loan (IFAD, 2012). In agriculture, they are used to trigger income-generating activities of smallholders, such as the provision of seeds, or simply for equipment. Given the fact that other standard financial instruments either do not promise high leverage effects (savings) or might be too risky for the extremely poor (loans), matched grants can be a way to promote new technology, even for a target group that is less likely to benefit from the use of financial services (IFAD, 2012). However, matched grants should only be applied wherever they can be used as a smart subsidy, that is, in an environment where they will not distort the market and have the chance to make a tangible difference by lifting up the beneficiary.

Loan guarantee schemes

Finally, one possible solution to the challenge of insufficient securities for machinery loans, at least partially, is a loan guarantee fund. Loan guarantee funds are financial instruments to reduce the risk for lending institutions against non-repaying clients. Typically, guarantee schemes replace or reduce the need to provide regular bankable guarantees on the side of the borrower. A loan guarantee is an agreement that part of the loan default will be borne by the guarantee fund against a certain guarantee fee (Zander, Miller, & Mhlanga, 2013). Hence, the lending risk is shared between the actual lending institution and the guarantee fund, which effectively provides a substitute for collateral.

The rationale for setting up guarantee schemes is often very clear: motivating lending institutes to start lending – or increase their lending – to a certain target group that is considered worth promoting. These are, in many cases, micro, small and medium-sized enterprises, and often specifically rural and agricultural enterprises. Numerous agricultural loan guarantee funds exist across Africa, in most cases set up by donor agencies as a development-finance instrument to increase access to finance for the agricultural sector. Examples are the Nigerian Agricultural Credit Guarantee Scheme Fund,

the Agricultural Business Initiative Trust in Uganda and several guarantee agreements that have been closed under the Alliance for a Green Revolution in Africa in Kenya and Tanzania, among many others (Zander et al., 2013). The guarantees are commitments that reduce collateral requirements for clients that are otherwise creditworthy and want to finance a commercially viable investment.

Loan guarantees are provided in different forms and under various institutional set-ups. In past decades, individual loan guarantees prevailed, whereby the (partial) guarantee coverage was linked to one individual loan. In recent years, guarantees are often set up to secure whole loan portfolios in order to reduce efforts and related costs for individual client analyses. A new form of guarantee is what is called a “portable guarantee”: a guarantee that an individual borrower can apply for in relation to an investment project; once it is received by the guarantee company, the borrower can then use this when applying for a loan at a financial institution (Zander et al., 2013). With decreasing individual loan amounts, a portfolio guarantee is more suitable than individual loan guarantees. The guaranteed value of the loans is typically between 50 and 70 per cent, but it can also be much less or more.

Guarantee schemes are classified as non-financial institutions but must be regulated and supervised. Ownership can be public or private with either a commercial or a non-profit objective. Guarantee funds can be linked to a financial or other institution or set up as a stand-alone entity (IFAD, 2014a).

Especially in the context of agricultural finance, loan guarantee funds are often associated with high hopes and are expected to provide a risk-management tool that will help financial institutions to build up their agricultural portfolios. But the (few) studies available show very mixed results and are especially critical about the long-term impacts and efficient use of donor funds (Zander, Miller, & Mhlanga, 2013). Assessments indicate that guarantee funds help to grow the desired target-group portfolio, but only as long as high guarantees are provided. Also, procedures and management have been criticised for a lack of efficiency and professionalism. Meyer (2015) also highlights that guarantees cannot solve underlying regulatory or structural problems in markets and underlines the need for creating a conducive market environment for lending to the desired target group and combining guarantees with the comprehensive capacity-building measures of lenders.

From the current analyses on loan guarantee funds, a number of important lessons can be highlighted and reveal a high relevance for financing mechanisation. First, and probably most importantly, clients that benefit directly (or indirectly through a portfolio guarantee) from a guarantee should be creditworthy, and their investment project should be commercially viable as such. The only missing piece should be a lack of formal collateral, which the guarantee then can provide. It is important that the financial institution that makes use of the guarantee takes a significant share of the risk – to avoid moral hazard in its decision-making concerning lending. It should also have demand-oriented products in place, have adequately trained staff and be willing – as per its internal strategy – to serve financing needs related to agricultural mechanisation, and not only do so once a guarantee scheme is put in place (IFAD, 2014a). Loan guarantee funds can then be a suitable instrument to foster the financing of mechanisation, as they lower formal collateral requirements, especially for representatives of RW 3, who may have highly commercially viable projects but who lack classical collateral, such as formal land titles and real estate, and are thus excluded from access to finance. Nevertheless, before setting up a dedicated guarantee scheme, the market demand must be duly assessed, as well as the capacity of the target clientele to pay for the guarantee fee (IFAD, 2014a). In other words, investment in mechanisation must bring enough revenue to cover the additional costs for a guarantee, given the lack of own collateral. For a guarantee scheme to be sustainable, it should be designed and priced in such a way so as to recover the loan default costs through its fee scheme.

Payment systems and digital financial services

Sending and receiving money and payments can be realised with money-transfer services, both at the national and international levels. Generally, formal services reduce costs and risks related to transferring money. Money-transfer services and payments matter, for example for purchasing mechanisation equipment (e.g. paying loan instalments without expensive and time-consuming travelling, or easy access to transfers from family members).

Another distribution channel is based on the innovation of digitalisation. Although lagging behind in several other aspects of financial-sector development, SSA is a frontrunner in digital money financial services (DFS), that is, using mobile and web-based devices to transfer money (Babcock, 2015). Experts are in unanimous agreement that DFS are contributing significantly towards reducing transaction costs for the provision of rural

and agricultural financial services (G20 GPFI & SME Finance Sub-Group, 2015). Loan payouts as well as the payment of instalments can be conveniently transferred via mobile phone. An important aspect, however, is to ensure that farmers and agro-SMEs are capable of making well-informed use of these options (G20 GPFI & SME Finance Sub-Group, 2015).

Overview of financial products

In general terms, financing needs are related to the respective RW and the capital-intensity of a machine. Furthermore, some financial services, such as efficient money-transfer options, are necessary to facilitate a machine service provider model where person-to-person money transfers are required. Or, specific loan technologies must enable a shared ownership. The following table disaggregates this for the distinct RWs.

Table 7: Intensities of mechanisation and suitable financial products per RW to buy a machine				
	Hand tools	Drought animals*	Small machines*	Large machines
RW 1	<ul style="list-style-type: none"> • Payment systems 	<ul style="list-style-type: none"> • Money transfer • Loans 	<ul style="list-style-type: none"> • Money transfer • (Leasing) • Insurance 	<ul style="list-style-type: none"> • Money transfer • Loans • Credit line • Leasing • Insurance
RW 2	<ul style="list-style-type: none"> • Money transfer • SME loans • Insurance 	<ul style="list-style-type: none"> • Money transfer • SME loans • SME leasing • Insurance 	<ul style="list-style-type: none"> • Money transfer • SME loans • SME leasing • Insurance 	<ul style="list-style-type: none"> • Money transfer • (SME loans) • (Credit line) • SME leasing • Insurance • Guarantee
RW 3	<ul style="list-style-type: none"> • Money transfer • Micro loans • Targeted savings • Micro insurance 	<ul style="list-style-type: none"> • Money transfer • Micro loans • Targeted savings • Micro insurance • Guarantee 	<ul style="list-style-type: none"> • Money transfer • Micro loans • Targeted savings • Micro insurance • Guarantee 	n.a.

Table 7 (cont.): Intensities of mechanisation and suitable financial products per RW to buy a machine				
	Hand tools	Drought animals*	Small machines*	Large machines
RW 4	<ul style="list-style-type: none"> • Money transfer • SME / micro loans • Targeted savings • Micro insurance 	<ul style="list-style-type: none"> • Money transfer • SME / micro loans • Targeted savings • Micro insurance 	<ul style="list-style-type: none"> • Money transfer • SME / micro loans • Targeted savings • Micro insurance 	n.a.
RW 5	Matching grants	n.a.	n.a.	n.a.

*Note: Drought animals and small machines tend to be in a similar price category.
Source: joyn-coop (n.d.)

4.3.3 Landscape of financial service providers

As a result of the financial systems approach over the last two decades, the landscape of institutions we can find in SSA has become more diverse. Throughout the literature on agricultural and rural finance, several attempts have been made to categorise and cluster types of financial service providers (e.g. Höllinger, 2011; Meyer, 2015; Initiative for Smallholder Finance, 2013a). A typical classification is to differentiate between commercial banks, microfinance institutions, member-owned financial institutions and informal models that facilitate specific financial management practices. The different cases analysed show, however, that it is the design and product technologies that seem to be the most important success factors in financing mechanisation, not the institution providing them. Still, different institutional types are more or less capable of – or likely to – provide certain products (e.g. microfinance institutions may be restricted in savings collection and the provision of larger loans). We have identified several dimensions that influence how financial service providers behave as well as the range of financial management needs they are able to address.

An institution's legal status and regulation by the financial-sector authority is crucial for the types of product that can be offered. Typically, unregulated institutions are not allowed to collect savings, with the exception of member-

based institutions that decide to do so through enforcement of their own statutes for their members. Regulated institutions often face higher operational costs, as they must meet and prove they have meet certain standards.

Ownership (public versus private, as well as foreign versus domestic) determines the level of influence by the government and may define the degree to which a financial institution can tap into public funds, for example for business development or use of subsidies. Local financial institutions typically have the advantage of knowing their clients' needs and situation well, but they typically lack outreach and regional as well as sectoral diversification in their client base, which impedes portfolio-based risk-mitigation strategies. Member-based institutions, such as savings and credit cooperatives or village banks, often are locally rooted and driven by a certain purpose (e.g. community development), but in many cases these institutions lack in-depth banking know-how and product diversification.

The purpose driving an institution is particularly relevant in the context of donor interventions or participation in special development programmes: Does a financial institution commit itself to social or environmental objectives, next to commercial targets (e.g. with double or even triple bottom line principles³⁶)? This will have an influence on product types, portfolio sizes, outreach and client as well as needs-orientation. Financial-sector experts have confirmed that whether a financial institution decides to venture into agricultural finance will primarily depend on its core strategy and business concept, in addition to the options that the market offers them and their technical capacities (Wiedmaier-Pfister, 10/2015; Kortenbusch, 10/2015).

For financing mechanisation, all different types of institutions are relevant, according to the financial systems development approach. Interestingly, our analysis shows that the extreme ends of client types' needs are being met much better already than those of the middle: commercially oriented and supra-national banks (and leasing institutes) are the ones to finance large mechanisation efforts by serving the commercial farmers of RW 1. This

36 The double bottom line refers to addressing economic and social objectives simultaneously. In microfinance, Social Performance Management is an instrument to address the social dimension in a systematic manner (e.g. preventing overindebtedness of clients; see Social Performance Task Force, 2016). Adding environmental objectives (e.g. no financing for environmentally harmful businesses), an MFI aims then to achieve a tripple bottom line (see Schuite & Pater, 2008).

is already happening. Additional efforts can be made to better link these commercial farmers with smallholders. On the opposite side of the spectrum, RWs 4 and 5 have increasing access to financial services through microfinance, member-based financial institutions and even village banks, which allow them to smoothen their consumption or buy services from a machine owner. On this side, models for further increasing physical outreach and decreasing the costs of client interactions and money transfers are core topics that need to be worked on more. Offering repayment models that are adapted to both seasonal and livelihood cycles is also very relevant to small farmers.

Rural banks could also take over a role in asset financing for medium to large machines, since they are specialised in the rural – and often agricultural – segments of financial markets, and often have rural branches or other outlets. An important precondition, however, would be that they form sound apex (umbrella) institutions through which individual affiliates can get access to medium-term refinancing. However, apex models often have governance challenges, as members have to control and govern themselves.

Public financial institutions such as agricultural development banks, if operating along commercial principles, could take up such a role and invest in the design of highly tailored asset-financing products for the (agricultural) SME loan segment, which could serve for machine financing. With some exceptions, in SSA most existing development banks are weak, often reflecting weak governance structures as well as poor capacities and/or the lack of available government budgets to allocate funds for rural development purposes. Until this is solved, a bottom-up approach of working with the private sector by supporting upfront business development costs is advised.

Microfinance or member-owned institutions have the advantage of knowing how to interact successfully with clients with lower levels of education and lower, more informal and volatile incomes. Some of them also have built up a presence in rural areas. However, it must be noted that the classical microfinance approach to lending is to work with small loan amounts that increase over time and with successful repayments. Payments are requested immediately after loan payout and repayment is frequent (at minimum weekly). These – and also some other core success factors in microfinance, that is, the small amounts, informal collateral and the absence of grace periods – are exactly the characteristics that do not match well with the financing of mechanisation for (individual) ownership, since they often do not allow for scaling-up over time and require large loan amounts and grace periods.

The actual and remaining challenge in financing mechanisation is to find sound models for asset finance that can make tailored investments into machines possible for farmers in RW 2. This challenge should be addressed by larger, more stable and experienced financial institutions, for example microfinance institutions (MFIs) and commercial banks. These have the internal structures and legal status necessary to attract refinancing, for which they need to provide the longer loan terms (3–5 years) that are necessary for financing small machines. Also, they can partner up with farmer groups for machine ring or leasing models.

4.3.4 Cost-effective distribution channels for financial services are key to scale

Next to the types of financial products and financial service providers, the distribution channels, that is, how and by whom a financial product is provided to the client, are being given increasing attention in agricultural finance. The classical – but less and less popular – distribution channel in banking has been the “brick and mortar branch”: if interested in a financial service, the client would go there and get served by loan officers. Then, microfinance inversed this model: the loan officer would go out and visit (groups of) clients to deliver the institutions’ services. Both approaches have high transaction costs: the latter for the financial institution, the former for the client. Microfinance-type client visits, however, are an effective risk-mitigation approach, as the loan officer can collect much information about the client. But MFIs are typically limited in the loan amounts they can offer and are, thus, partly not suitable for mechanisation finance.

Therefore, many efforts have been devoted towards optimising the distribution channels of financial institutions that can offer higher loan amounts, in parallel to the thriving innovations that communication technologies have brought forward.

First, banking became “branchless” by using mobile branches and small satellite offices. Then, with the outreach of mobile phone banking, the use of banking agents became popular to manage money transfer. As a result, financial institutions have gradually learnt to “outsource” their front office to third parties who act as intermediaries to their clients. However, there are other parts of the service delivery, such as assessment of credit clients, that need to remain at the core of the financial institutions – and also need to be performed in person. These parts are more important in mechanisation

financing, since the volumes are larger, usually not appropriate for groups and need individualised assessments of profitability and security (see above).

Value chain finance

A highly popular, increasingly successful and very relevant distribution channel for mechanisation is agricultural value chains. By learning to link up with existing cooperation structures and business relationships in the agricultural sector, financial institutions can leverage their services and indirectly reach out to more smallholders or SME agro enterprises while reducing risk and transaction costs. What is referred to as value chain finance comprises a wealth of varying models but, in essence, means “any or all of the financial services, products, and support services flowing to and/ or through a value chain to address the needs and constraints of those involved in that chain ...” (Miller & Jones, 2010).

The underlying principle is that the risk of lending can be reduced if one value chain participant can provide references or a guarantee to a financial institution for another value chain actor, given their close, trustful or commercially non-separable relationship. The basis is a documented or firmly established business relationship between those two value chain parties. On this basis, the financial institution decides to cooperate with one of the two parties, knowing that a reliable business case exists. Examples are traders or processors along a value chain who provide guarantees for their farming business partners (Nordmann, 12/2015). Such guarantees are then reflected in tripartite agreements between two value chain actors and the financial institution. Such a model is referred to as “external value chain finance”. In an example of the Tanzanian sugar associations, two tripartite agreements were even combined to cover the farmers’ diverse financing needs: farmers received a loan from a financial institution based on guarantees provided by the off-taker, and the off-taker advanced additionally a loan on its own books through another financial institution to farmers (International Finance Corporation [IFC], 2012).

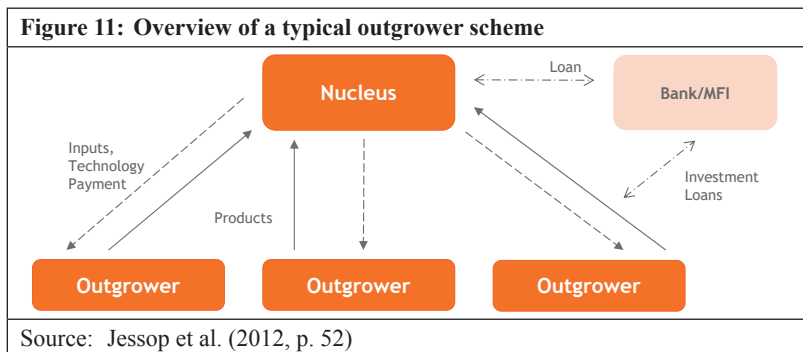
Financial solutions also can be provided directly through value chain actors, for example through loans from buyers to suppliers. A buyer might have access to bank financing and can then provide loans to its suppliers, based on a trustful and established relationship with them. This is referred to as “internal value chain finance” (Miller & Jones, 2010).

Value chains can be leveraged for financing mechanisation: financial service providers can, for example, analyse in how far productivity gains

from a new machine can be used to secure mechanisation funding within a value chain, or co-ownership models of machines can be facilitated among value chain stakeholders. Furthermore, machinery supply chains can play an important role in financing: for example, a machine supplier can provide or arbitrate intra-value chain finance to the clients who buy machines, as they typically have an excellent level of understanding of how a machine is integrated into a farm enterprise. Such examples are popular in Germany, where machine producers organise leasing or financing contracts to their clients in cooperation with a bank (e.g. Grimme, based in Germany).

Contract farming: Financial services linked to outgrower schemes

Another very relevant distribution model for the financing of mechanisation are outgrower schemes. Outgrower schemes are contract farming schemes with a high degree of market integration. They are often set up by financially strong agro-processing enterprises (the “nucleus”, often also owning a plantation), which contract surrounding smallholder farmers for crop delivery against a set of embedded services: delivery and financing of inputs, synchronised production, processing and post-harvest logistics, and non-financial services such as extension (Will, 2013). Access to machinery can be provided directly (outgrowers can use the machinery owned by the “nucleus” for a fee) or through value chain finance (see above). So far, such outgrower schemes mostly link larger commercial enterprises with smallholders. The results of these business relationships can be quite ambiguous for smallholders, depending on their position to the off-taker and the conditions of cooperation agreed upon, because “in their worst form [...], contract farming deserves its reputation of turning producers into wage labourers on their own land” (OECD, 2006, p. 59).



4.4 Success factors and guiding principles for mechanisation finance

Highly adapted, client-centred products, which are at the same time cost-effective to offer, are the key to agricultural finance and equally to financing mechanisation. So far, only very few products have been specifically designed for the purchase of agricultural machinery. Most suitable, in theory, are leasing products. But the development of an efficient leasing market in most sub-Saharan African countries is still limited due to regulatory factors. If available at all, agricultural machinery leasing is used for very large machinery only, but this does not provide the necessary impetus to support sustainable agricultural transformation in SSA, where the majority of (mechanisable) farms are from RWs 2 and 3. As shown above, investment in high-intensity machinery is not suitable for all farm types and sizes, but only makes economic sense for larger agro-enterprises, or when establishing models of sharing or service provision for machinery use. The following principles are meant for these huge market segments or lower-level RWs, which are not covered easily by commercial leasing or credit.

Guiding principles for financing mechanisation

For future donor activities to promote sustainable mechanisation through the financial sector, we have derived the following guiding principles.

Financing profitable investments

As a starting point, any investment in a machine must be profitable. A financial institution should duly consider the income that the introduction of this machine can generate on the farm and household levels in order to be sure that a client will be able to service its investment costs and generate the necessary additional income. Costs should include – at least in the long run – also the loan guarantees that a sustainable guarantee scheme should cover with its fee scheme. This means that the farmer needs to have the necessary market linkages and knowledge to successfully move upwards on the profitability / risk continuum. Continuous or multi-purpose usage of the machinery will contribute to its profitability.

Triple bottom line

At an aggregated level, lower-intensity and adapted technologies are found to have more positive economic, social and environmental effects in SSA. A

well-adapted mechanisation can thus contribute to social and environmental development goals while being economically viable. However, it has been shown that several mechanisation options bear various environmental risks, at least partially independent of size. Exclusion lists or incentives regarding environmentally friendly mechanisation options can be used by financial service providers to reduce these risks. However, they need to be elaborated in the specific context of each agro-ecological zone and might differ for distinct farming systems.

Product range

To support a mechanisation that brings the highest benefit, that is, according to triple bottom line principles, a range of well-tailored financial services (“bundle”) should accompany the mechanisation process where necessary (e.g. loan plus insurance plus efficient money transfer). For small-scale farmers and processors (e.g. RWs 2, 3 and 4), savings products, money transfers and small loans to pay for machine hiring should be promoted.

Product adaptation

Any financial product should take account of the income and expenditure streams of farmers. The better a financial service provider knows the use patterns and income generation related to a machine vis-à-vis the overall farm enterprise or household, the better a financial product can be adapted to its purpose. Unlike top-down approaches to product design, a financial service provider should seek to learn directly from the customers so that product features can address the needs, constraints and capacities of a client. To overcome barriers related to offering services to rural clientele, commercial banks especially should learn to work with alternative collateral, for example warehouse receipts or value chain finance. Upfront investment in agricultural sector market intelligence, staff capacity to analyse agro-enterprises and client segmentation could be co-financed by donor organisations.

Cost-effectiveness

When designing any financial product, attention to cost-effectiveness should be high, as financial margins in agricultural production, especially for food crops, are often very low. In the case of mechanisation, cost-effectiveness is particularly important, due to its term financing nature. The aggregation of

clients to reduce the number of contact persons and direct interaction with smallholder groups have shown to contribute greatly to cost-effectiveness. The promotion of the financial education and business literacy of clients is also an important driver for cost-effectiveness, as it eases the interaction between a financial institution and its clients, but it is typically not provided by private financial institutions. For this, special capacity-building schemes need to be developed, that is, in the context of national financial education strategies that are steered by the public sector (e.g. the central bank). Using DFS is associated with major cost savings in reaching out to rural clients.

Timeliness

Agriculture is a highly time-sensitive economic activity, especially in rain-fed agriculture, which is typical for SSA. Therefore, financing needs must be addressed in a highly timely manner so that customers can take advantage of suitable weather conditions or other external opportunities that are conducive to their agricultural activities. This is particularly important for input finance accompanying mechanisation finance, or for the timely start of machinery use. Timeliness and time-bound use also needs to be taken into account when shared ownership of machinery is financed.

Use of subsidies

Agriculture is politically sensitive, as politicians are inclined to engage in quick-fix solutions to show their engagement to the rural populations. These activities might, however, be unsustainable and lack a long-term vision. The use of direct subsidies for interest rates is considered bad practice by many financial-sector experts – unless it is clearly supporting public goods – and should be avoided. For very poor farmers, matching grant models or social transfers should be considered instead.

Indirect subsidies in the form of smart subsidies, for example via smart loan guarantee funds, upfront investments into market intelligence and staff capacity (technical assistance) or used in carefully designed promotional loans – have shown positive results and can trigger private-sector involvement to induce market growth.

5 Conclusion

With agriculture's central role in food security and (pro-poor) development, it is time to have a fresh look at mechanisation. Analysing last century's literature, we saw that many of the insights on mechanisation still hold true for SSA, where the level of mechanisation has been persistently low. However, a changing societal context and different market and agro-ecological conditions in SSA underline not only the need, but also the opportunity for new mechanisation efforts. The persistent relevance, the renewed interest and new opportunities for mechanisation in SSA have been confirmed by the scientists, practitioners and donors we were in contact with throughout the research. The lessons from the past and an overall more conducive set of framework conditions will help to shape sustainable new endeavours to foster mechanisation – and provide the necessary financing for it.

The study set off with the idea of bringing the sectors of agriculture and finance closer together with the overall objective to fight food insecurity in SSA. We think that it is worthwhile to walk the extra mile of considering both perspectives when looking at agricultural finance – and at mechanisation in particular – because it opens up new possibilities for advancing towards adapted and meaningful changes: policies, projects and financial-sector innovations need to be based on combined knowledge and joint reflection. This is especially important as mechanisation can contribute to food security and pro-poor development, but it also carries important risks: it changes both the agronomics and the economics at the farm level and affects other rural actors, too. This is why we think this more holistic perspective on financial inclusion makes sense. It is important to not only analyse possible financial services and modes of access for the rural populations, but also to understand the changes induced by a specific investment (mechanisation) for the farmer, her family and her environment. This reduces the risks for both the farmers and the finance providers and helps to create better products that are better adapted to the farm and households situations, which ultimately improves both repayment rates and scaling-up.

This combined analysis is not only useful from an analytical perspective, but is also found as an emerging trend for successful agricultural (and mechanisation) finance in practice: donors and development practitioners bring together experts from different disciplines in order to identify sound solutions in cross-sectoral working groups. On the private-sector side, we observed that some financial institutions invest in agricultural expertise and

personnel with an agricultural background to strengthen their agricultural and mechanisation finance. As a result, the first interesting financial products have come into existence that take into account the respective regional agricultural production cycles, marketing structures and value chains. We also identified projects of agricultural companies that have started providing financial services to their partner farmers in support of production and mechanisation.

Why is this link between the agricultural and finance fields relevant in practice? Because financial products and services need to take into account the agricultural logic in order to be meaningful. This will help the development of specific products, guidelines and customer consultation that make the investment profitable – which lies in the interest of both the farmer and the financial institution. With well-adapted financial products, mechanisation can also be promoted for smallholders and serve the huge “missing middle” between very high- and low-cost investments, that is, particularly RW 2. Alternatively, agricultural companies can recommend appropriate ways of mechanisation, facilitate machinery-sharing schemes or get involved in the design of financial products that match well the financing needs during the agricultural cycle by using their business relationship to farmers as a (partial) collateral substitute. With an increasing degree of product adaptation, the exclusion of potential harmful impacts on the respective socio-environmental context can be achieved, for example by making use of exclusion lists. Still, the effects on other rural stakeholder in the short term – and particularly in the long term – are difficult to predict.

We have asked: What are the non-financial aspects of mechanisation, and how does mechanisation affect rural people and ultimately food security in SSA?

Most rural households in SSA face multiple risks and constraints – in their agricultural activities and beyond. In the absence of suitable insurance products, farmers choose to apply low-risk farming patterns and generally diversify income. These risk-management strategies – as well as other external factors such as limited access to input and sales markets, adequate machinery, infrastructure, knowledge and financial access – limit households’ capacities and demands for mechanisation.

Rural livelihoods in SSA are extremely diverse in socio-economic terms (RWs), but also agro-ecologically and culturally. Socio-economic and agro-ecological effects of mechanisation are thus ambiguous and highly context-

specific. For those farm enterprises and households that have direct access to using mechanisation, the productivity of labour and/or land may increase and working conditions improve. For others in the RWs, negative or positive employment and income effects may arise out of different mechanisation strategies: mechanisation can create new prospects for the young in rural areas, but also increase the concentration of farmland ownership and thereby shape the transformation processes of rural societies. For the farmers – particularly women farmers – reducing drudgery is another relevant aspect, while we have found that the attitudes towards mechanisation may differ for women and men due to cultural norms. Yet, traditional as well as mechanised farming techniques may have adverse or favourable effects on soils, climate and the environment in the long run.

Accordingly, the effects of mechanisation on the different dimensions of food security are equally complex, highly ambiguous and can hardly be generalised. If high-intensity mechanisation is implemented through large-scale, capital-intensive mechanisation schemes in RW 1, it may potentially contribute to rural underemployment and displacement, affecting the affordability of food negatively for some, while offering employment and market access to others. If high-intensity mechanisation is devoted to food production, transport and/or processing, it can not only improve local and regional food availability, but also reduce the incomes of competing food-selling smallholders. For concentration on export crops, the opposite impact pattern may hold. In RWs 2–4, lower-intensity mechanisation is generally more suitable, or high-intensity machinery can be suitable if co-usage or sharing arrangements are implemented, and if plot sizes and harvest quantities allow that type of mechanisation. Such adapted forms of mechanisation can contribute to the successful commercialisation of smaller farmers. It might also facilitate a shift of agricultural workers into supporting services (e.g. mechanics) and processing with improved income opportunities. In the long run, the mechanisation of small- and medium-scale farms and rural enterprises is also likely to constrain the risk of land consolidation, or even land grabs, while offering employment opportunities to greater shares of the rural populations. Food security can thus be strengthened both by improving smallholder productivity for subsistence and commercial production, and by increasing incomes for rural labourers. Still, increasing farm sizes of commercially successful machinery owners and users may transform rural structures gradually. It is crucial to always bear in mind that agricultural mechanisation needs to respond to a commercial logic in order to be

profitable. Increasing the commercialisation of mostly family-led farms in SSA implies important socio-economic and agronomic transformations, based on the intensification of cropping or spatial expansion, with differing consequences depending on the type of mechanisation and the availability of land, labour, knowledge and infrastructure. High utilisation rates of machinery, through multiple-purpose usage as well as sharing and service provision models, can enhance the profitability of the investment in mechanisation for both machinery owners and users.

Combined, the ambiguity of these effects shows that certain trade-offs between short- and long-term goals will be hard to avoid. Yet, mechanisation is needed in many cases for making agriculture and its value chains productive, attractive and competitive. This is particularly important to motivate (a part of) the youth to stay in farming and perceive it as an attractive future – economically and labour-wise. Often, mechanisation is a centrepiece of more radical changes of farming systems, such as the integration of animal and crop husbandry, intensification of organic and inorganic fertilisation or weed management. However, due to its diverging socio-economic and ecological effects across RWs, gender and landscapes, it must be implemented with great caution and diligence in order to bring about sustainable positive effects and avoid negative ones – or at least cushion painful adjustments for those affected.

Mobile technologies such as mobile phones offer opportunities for a new kind of digitalised mechanisation path, as has been shown in the Hello Tractor case study. The type of mechanisation and its use on different steps in the value chain is decisive not only for agro-ecological changes, but also for the effects on employment, economic growth, equity, as well as agriculture and food system performance – and hence for the type of rural transformation it will induce. From a macro-economic perspective, adapted medium technology constitutes a possibility for rural employment promotion in areas characterised by smallholder agriculture, although this might require subordination of economic growth goals to employment goals on an aggregate level. Not only the macroeconomic goals, but also structural change of rural areas can and must be guided and accompanied by policy and specific framework conditions: public investment in infrastructure and public services and incentives to keep processing and service industries in rural areas may improve livelihoods for all rural stakeholders. However, improving infrastructure and public services in rural areas is a huge challenge in most countries in SSA in general, as it requires enormous investments.

If mechanisation is to be promoted in the framework of a development programme, its ambiguous potential effects need to be analysed from the outset of programme planning, taking regional, cultural or project-specific contextual factors into account. The intensity, type and kind of mechanisation need to be carefully evaluated. Farmers need to be enabled to take informed decisions about their individual investments and business strategies for their farms.

We have explored: What are the financial aspects of mechanisation? How can access to finance for mechanisation be achieved?

Access to finance generally is a challenge in the rural areas in SSA, and especially for mechanisation. The latter can be explained by a more general set of challenges related to providing finance to the agricultural sector, whereas others apply specifically to financing agricultural machinery – which is typically a lumpy investment that needs to be financed over several years.

On the demand side for finance, this relatively large investment in mechanisation is the biggest challenge. A farmer or farming family needs to know and ensure that the investment will be profitable; to allow for loan repayment and the payment of working capital; and to bear the often high loan costs. The use of mechanisation also tends to change the risk patterns of farming activities, and these new or different risks need to be well understood and managed, too – ideally by using adapted insurance schemes.

On the supply side of mechanisation finance, general challenges of agricultural finance comprise the often insufficient understanding of the agricultural sector, and hence a perception of high risks, as well as the high costs of serving clients in remote areas who often have little financial and business literacy. In addition to this, machinery financing is term financing, that is, depending on the cost of the machine and the financial strength of a farmer, it takes one to five years to amortise. This implies a need for good cash-flow forecasting, sufficient securitisation with collateral and access to medium-term refinancing. Securitisation poses a major challenge because most farmers, especially in RW 3 (and 2), do not have classical bankable collateral such as transferable land titles or valuable real estate. Several options and good examples exist to undertake alternative securitisation. On the product side, this can be the use of leasing products, whereby the machine itself acts as collateral. But in SSA, leasing markets are barely developed, as regulatory aspects result in prohibitively high pricing. Other, more promising

forms of collateral alternatives comprise value chain finance and machinery supply-chain schemes, whereby existing contractual relationships between value chain actors from one chain are used as a guarantee for the investment. Another option is the cooperation with loan guarantee funds – an area where the public sector or donors could foster machine financing; but a highly efficient and transparent fund set-up will be necessary for its success.

The analysis on the non-financial aspect of mechanisation revealed interesting aspects, which play an important role in the identification of suitable mechanisation financing schemes. Most important is the need to match a machine's capacity to the scope of its use in order to make the investment profitable. Given the typical small farm size in SSA, most higher-intensity machines do not match common farm sizes – which impedes an investment. Shared-ownership models are one solution, in which either the ownership and/or the use of a machine is shared. The models are organised by farmers themselves, for example in machinery rings. Success strongly depends on the organisational and governance capacities of such joint-ownership models, and we could identify only a few success cases in SSA. A specific form of the shared-usage model in SSA consists in the provision of mechanisation services in outgrower schemes: larger farmers (e.g. in RW 1 or 2) buy machinery and allow contract farmers to use them against a payment or a share of the agricultural output. This also increases effective use and income for the owners. A promising approach seems to be the service model, that is, a set-up by an entrepreneur or larger farmer who buys machinery to hire it out to other farms, including smallholders. This model was a huge success in Asian countries, and it is currently spreading in SSA. Some related financial services are needed to facilitate these approaches, for example efficient money-transfer services to allow for the easy, quick and low-cost payment of hiring services.

In summary, the design of financial products (or product bundles, including e.g. insurance cover) for mechanisation should take into account such innovative shared ownership and co-use models, while being based on good agronomic knowledge and the specific usage patterns of farm machinery.

Outlook

The study showed that private-sector actors (must) cooperate across finance and non-finance frontiers along the value chain and within financial institutions. Financial institutions (must) incorporate agronomic knowledge

for target-oriented agricultural and mechanisation financing. Agricultural enterprises can facilitate arrangements with financial institutions or sometimes offer financial services as a complementary service to their partner farmers and outgrowers. For the private sector to successfully support meaningful mechanisation, the institutional environment is a crucial success factor.

Failed state-led mechanisation initiatives and directed credit schemes of the past have shown the difficult political economy of agricultural and mechanisation promotion and financing: people of the five RW live in very different livelihood conditions, with diverging levels of access to information and political power. When machinery and/or loans were “provided” at (highly) subsidised prices or interest rates, corruption and clientelism often facilitated access for wealthy farmers outside the actual target group, but with significant local or political power. State support to the poor and low-income populations is fundamental, but it is decisive how this support is being provided. Stable rules and, ideally, fair opportunities (level playing fields) are fundamental for all businesses – including financial institutions – to operate successfully. Populist credit-forgiveness initiatives or election-preceding gifting of agricultural machinery have generally had the effect of destroying the respective markets for these services and goods, rather than providing equitable access for all.

Still, public intervention is much needed beyond the establishment of a conducive environment. The private sector alone will not fund enough machinery to support a successful modernisation strategy or even to keep pace with new requirements of agricultural production in a changing economic, social and ecologic environment. Under current circumstances, risks and costs are still very high for fully market-led mechanisation finance. At the bottom of the pyramid or in high-risk areas, thus, complementary interventions of public actors – both states and development cooperation – are key. They can go the “extra mile” to reach the poor and contribute to food security and pro-poor development goals by:

- strengthening the enabling environment for the private sector and rural populations with adequate and stable rules and regulations;
- encouraging private-sector actors to take on high-risk or start-up costs, for example with guarantee schemes for risky but meaningful investments, matching grants for the poorest and support for institution-building in areas of market failure;

- avoiding direct subsidies for interest rates. Subsidies may only be considered if they can be designed in a way to address a clear market failure or to support a population group that suffers from structural disadvantages. Any use of subsidies should be designed “smart” to foster market growth and represent the final interest of its receivers (and not of the state, e.g. to foster power), and must be set up in a way that prevents fraud or misuse;
- monitoring the indirect and long-term effects, and improving and adapting the respective mechanisation strategy applied – and possibly by responding with programmes to cushion the consequences for negatively affected vulnerable populations (e.g. landless labourers) or negative external effects (e.g. availability of water);
- always keeping in mind that mechanisation must be commercially viable for all involved actors in the medium term. However, there is plenty of room for meaningful support of framework conditions. This may be through fostering financial and business literacy at the farm level; product development skills at the level of financial institutions; research for adapted models and usage of mechanisation; or adaptations of relevant laws and regulations.

Development cooperation can support learning, information exchange, platform-building and subsidise pilot projects. Systematic attention must be given to designing pilot projects in a way that their lessons can be used in different contexts and for scaling-up. For successful interventions in agriculture (with pre-defined agronomic and business cycles), the possibility to accompany meaningful projects until they reach “maturity” is important. This needs time. Finally, the development-enhancing promotion of mechanisation should always consider both the non-financial and the financial aspects of mechanisation. The following areas of intervention can be addressed.

- At the micro level, that is, at the level of the market actors, training is very relevant – agronomic, machinery-related and business skills (cost-benefit analysis of machinery investment) for farmers and specific courses in agricultural finance and product development for financial institutions. The latter can furthermore be strengthened through the promotion of concepts for alternative securitisation and equipment value chain financing and the provision of long-term refinancing.

- At the meso level, that is, at the level of the market structure and support institutions, it is important to create or develop moveable collateral registries and comprehensive databases on agriculture calendars, risks, costs, prices, etc., which banks can use for improving internal risk management for agricultural and mechanisation financing.
- At the macro level, that is, where policies and regulations are decided and supervised, the central challenge is the creation of a level playing field in the agricultural and finance industries and the improvement of rural infrastructure and access to public services. This includes suitable tax schemes for the import (or production) of machinery, or for leasing. If grant schemes are desired – for example for providing small machinery to the poorest or working with an agricultural development bank – setting high standards for monitoring and supervision is central.

Most importantly, all actors related to promoting mechanisation should have in mind that its central profitability is generated at the farm level. Suitable financial products that are tailored to the various use and ownership models will help foster mechanisation. There is a great necessity to adapt machines to the specifics of the various ecological zones and agricultural production patterns across SSA. Machines need to be robust, easy to handle and allow use for various purposes. There is yet much to be learnt about suitable machines and mechanisation models that fit the different – often challenging and highly varying – circumstances across Africa.

To ensure the profitability of an investment in a suitable machine, financial products should be based on solid agronomic knowledge and a thorough analysis of the business case for mechanisation. The promotion of mechanisation by public actors should always be indirect and respect the central commercial logic of mechanisation; this can include training farmers and relevant institutions. This will be time-consuming, but it is necessary to promote a sustainable path to mechanisation in SSA. At the same time, the effects on other rural populations have to be analysed in every context.

The current low levels of mechanisation in SSA represent a challenge, most of all for the farmers themselves. Against the background of high population growth and food insecurity, sustainable mechanisation is a necessity. For SSA, this is a stony path – but one that is worthwhile engaging in.

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Annexes

Annex 1: List of interview partners					
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)	
Adler	Matthias	Kreditanstalt für Wiederaufbau (KfW), Germany	Head of Division Infrastructure and Financial Sector West Africa	11/11/2015	
Agwe	Dr. Jonathan	International Fund for Agricultural Development (IFAD), Italy	Senior Technical Specialist – Inclusive Rural Finance Services	27/10/2015	
Anderson	Jamie	Consultative Group to Assist the Poor (CGAP), USA	Financial Sector Specialist	07/10/2015	
Armbruster	Dr. Paul		Senior Consultant	03/11/2015	
Bamba	Souleymane	Individual Consultant, Ivory Coast	Agricultural Finance Specialist	08/10/2015	
Baumgartner	Dr. Philipp	IFAD, Italy	Associate Technical Specialist – Rural Markets and Enterprises	27/10/2015	
Bertenbreiter	Wolfgang	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), Germany	Senior Project Manager	12/10/2015	
Bishop-Sambrook	Clare	IFAD, Italy	Lead Technical Specialist – Gender and Social Inclusion	27/10/2015	
Breuer	Dr. Thomas	GIZ, Germany	Sector Project Lead – Agricultural Trade and Value Chains	20/10/2015	

Annex 1 (cont.): List of interview partners					
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)	
Collis	Bill	International Maize and Wheat Improvement Center (CIMMYT), Bangladesh	Senior Project Leader	05/11/2015	
Curtis	Matt	United States Agency for International Development (USAID), Bangladesh	Private Sector Engagement Team Lead	20/10/2015	
Delve	Dr Robert	IFAD, Italy	Senior Technical Specialist – Agronomy	27/10/2015	
Dixon	Dr John	Australian Centre for International Agricultural Research (ACIAR), Australia	Senior Advisor for Cropping System Economics	19/10/2015	
Eichenhauer	Irina	KfW, Germany	Sector Economist – Sector Policy Unit Financial Sector Development	19/01/2016	
Geyer	Constantin	KfW, Germany	Vice President	14/12/2015	
Girard	Pierre	Fondation pour l'Agriculture et la Ruralité dans le Monde (FARM), France	Project Leader Sustainable Production Systems and Advisory Services	09/10/2015	
Gohl	Dr Eberhard	Impact Plus, Germany	Founder & Senior Consultant	22/10/2015	

Annex 1 (cont.): List of interview partners					
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)	
Hamp	Dr Michael	IFAD, Italy	Lead Technical Specialist – Inclusive Rural Financial Services	27/10/2015	
Haque	Aklima	USAID, Bangladesh	Project Management Coordinator	20/10/2015	
Havard	Michel	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Burkina Faso	Researcher – Agricultural Economics	30/10/2015 (in written form)	
Hédan	Clémentine	LFS Consulting, Germany	Microfinance Consultant	02/12/2015	
Heyl	Julia Nana	Food and Agriculture Organization of the United Nations (FAO), Italy	Sociologist, Gender Specialist – Rural Infrastructure and Agro-Industries Division	29/10/2015	
Hilmi	Martin	FAO, Italy	Agri-Food Enterprise Development Officer – Market Linkages and Value Chains Group	29/10/2015	
Höllinger	Dr Frank	FAO, Italy	Economist and Rural Finance Specialist	26/10/2015	

Annex 1 (cont.): List of interview partners					
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)	
Keller	Peter	Independent Consultant, Germany	Former Director African Cashew Initiative (GIZ)	29/09/2015	
Kessler	Dr Christoph	KfW, Germany	Division Chief – Agriculture, Water, Biodiversity – West Africa and Madagascar	15/10/2015	
Khalilov	Anar	USAID, Bangladesh	Senior Food Security Advisor	20/10/2015	
Kienzle	Dr Josef	FAO, Italy	Agricultural Engineer – Plant Production and Protection Division	29/10/2015	
Knierim	Laura	KfW, Germany	Project Manager – Financial System Development and Regional Funds Southern Africa	05/11/2015	
Koffi	Mourife	ZAMACOM SA, Ivory Coast	Senior Agronomist	12/11/2015	
Kortenbusch	Michael	Business & Finance Consulting (BFC), Switzerland	Managing Director	27/10/2015	
Lund Lesa	Anja	IFAD, Italy	Consultant for Gender, Youth and Rural Development – Strategy and Knowledge Department	27/10/2015	
Malik	Waqas	GIZ, Germany	Consultant	20/10/2015	

Annex 1 (cont.): List of interview partners					
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)	
Matthes	Dr Hartmut	Claas, Germany	Director of Claas Central Academy	16/10/2015	
Miller	Calvin	FAO, Italy	Retired (Former Senior Officer and Leader – Agribusiness and Finance Group)	29/10/2015	
Mmbughu	Abadiel	Tanzania Federation of Co-operatives (TFC), Tanzania	Research and Marketing Officer	15/10/2015	
Mwaura	Winnie	Equity Group Foundation, Kenya	Research Analyst	16/11/2015 (in written form)	
Neubert	Dr Susanne	Seminar für Ländliche Entwicklung (SLE), Germany	Director	16/10/2015	
Nitsch	Ulrike	Deutsche Investitions- und Entwicklungsgesellschaft mbH (DEG), Germany	Vice President	07/10/2015	
Njima	Peter	Equity Group Foundation, Kenya	Programme Coordinator	16/11/2015 (in written form)	
Nordmann	Frank	Grimme Landtechnik, Germany	Global Food Partnership Spokesperson, General Sales Manager Africa	01/12/2015	
Obrist	Marcel	Aqua Alimenta, Switzerland	Project Coordinator East Africa	05/10/2015	

Annex 1 (cont.): List of interview partners				
Name	First name	Organisation	Position / field of expertise	Date of interview (dd/mm/yyyy)
Owusuansah	Mark	Outgrower and Value Chain Fund (OVCF), Ghana	Fund Manager	21/10/2015
Peltzer	Roger	DEG, Germany	Director Development Programs and Business Support	30/09/2015
Rathayake	Anushka	myAgro, Mali/Senegal/USA	Founder & CEO	03/11/2015
Roy	Aniruddha	USAID, Bangladesh	Private Sector Advisor	20/10/2015
Sims	Brian G.	Independent Consultant, UK	Agricultural Engineer	11/12/2015
Singh	Zoravar	Equity Group Foundation, Kenya	General Manager Agriculture	16/11/2015 (in written form)
Steinwand	Dr Dirk	GIZ, Uganda	Head of Program Agricultural and Rural Finance	22/10/2015
Twomlow	Dr Stephen	IFAD, Italy	Regional Climate and Environmental Specialist	27/10/2015
Warrington	Mike	One Acre Fund, UK	Microfinance Partnerships Manager	26/11/2015
Wiedmaier-Pfister	Martina	Independent Consultant, Germany	Consultant Financial Systems Development	19/10/2015
Zander	Dr Rauno	Independent Consultant, Italy	Consultant Development Banking for FAO	29/10/2015

Annex 2: Case studies

1 myAgro: Targeted savings with innovative distribution channels

Organisation: myAgro is enabling access to finance for smallholders in rural areas of Mali and Senegal by offering an innovative layaway model to help farmers emerge from subsistence agriculture. myAgro's integrated approach aims at overcoming typical barriers to the financing of agricultural inputs and tools for farmers in the Sahel zone while ensuring profitability through delivery and support structures. Their model offers important insights for financing of low- to medium-intensity mechanisation.

MyAgro scratch card



© myAgro

Product: myAgro has developed a *layaway system*, allowing farmers to save money for buying agricultural inputs via their mobile phones. In selected villages, the organisation collaborates with local vendors that sell myAgro scratch cards of various amounts (US\$ 1–50) to farmers who have registered with the organisation. Via purchase of the scratch card, farmers can lay away small amounts of cash savings by texting the code from a scratch card to an indicated number. This way, they can target savings for a defined purpose. Clients determine their savings goal – an input / tool package for a certain amount of hectares – a priori and thus cannot spend the money differently. In order to guarantee that acquired inputs are brought to full use, myAgro also includes non-financial training and support services: in the planting season, the organisation sends out agents to the participating villages who advise clients on climate-smart and input-saving farming techniques, such as the micro-dosing of seeds and fertiliser. Timely delivery of inputs to a convenient distribution location is guaranteed by the organisation as well. This will reduce transaction costs for the farmers and ensure that inputs and tools are available when needed – a crucial aspect in remote areas of SSA. At harvest time, myAgro also conducts trials on

Farmers in Senegal using a *semoir*



© myAgro

how to facilitate market access for farmers. All inputs and tools on offer are quality-tested to ensure their yield-enhancing effect. myAgro also adapts tools to local needs, especially the needs of women.

Although myAgro primarily offers farming inputs, most packages also include small tools such as a planting stick, allowing for a more effective application of inputs. “Lead farmers” can acquire a *semoir*, an animal-drawn tool already widely used in Senegal, to simplify the planting process and rent it out to neighbouring smaller farms.

Effects: The most direct effects are that myAgro farmers profit from income increases from sales of increased harvests. The organisation estimates that farmers also increase their investment with myAgro, saving an additional 27 per cent in their second year of working with the organisation, and increasing their cultivated area by 12 per cent.

Lessons learnt for financing mechanisation: The myAgro approach demonstrates how new technologies can be used to expand financial services into the rural sector with innovative solutions by overcoming specific barriers to finance and savings. myAgro has designed its approach to be as user-friendly as possible for the participating farmers. No behavioural change is required from farmers in this savings system, as they can top-up their accounts with little amounts of savings whenever money is available while using the local store, which they visit for shopping purposes anyway. Thus, farmers do not incur additional transaction costs, and they work with an individual – the shopkeeper – they already trust. They are trained by myAgro’s field agents on modern planting techniques. Importantly, this system also provides a private and confidential way of saving, allowing people to “hide” their wealth from their families in order to circumvent redistributive duties that usually arise in solidary family systems. It also overcomes common problems in traditional savings group models, where transparency about everyone’s finances can cause conflict. Additionally,

those groups do not account for the fact that, in homogenous agricultural communities, the financial needs of the community members all occur at the same time. Thus, a mutual credit system is unlikely to work, whereas the layaway system allows for meeting all demands at crucial times in the growing cycle.

The organisation's test phase revealed a high demand for low-intensity mechanisation in Mali and Senegal. For acquiring *semoirs*, myAgro had farmers choose between layaway and small loans – and the majority preferred to save rather than take out a loan. Yet, savings alone might often not be sufficient to save up for larger investments. Layaway systems are very helpful for ensuring that savings are used for their dedicated purpose – they are therefore very promising for financing not only inputs, but also small-scale, low-intensity mechanisation. Currently, the layaway system is being scaled-up in SSA. According to the myAgro founder, Anushka Ratnayake, the profitability of the system would allow application by the private sector as well.

The organisation's integrated approach offers important insights – also for financing mechanisation in general: where remoteness inhibits agricultural households from accessing markets and information, these barriers have to be overcome to guarantee that access to finance can be transformed into sustainable effects. Where intra-family duties of redistribution exist, confidential access to savings is crucial – not only for financing inputs. Finally, yet importantly, the example illustrates the important match between high-quality inputs, adapted tools and machinery, and knowledge – as one is of very limited use without the others.

Sources:

<http://www.myagro.org>

Interview: Ratnayake, 11/2015

2 FACASI: Innovative business models for machinery distribution and supplementary services in SSA

Context: Tractor-hiring schemes have largely failed in SSA, and the majority of smallholder farmers still rely solely on muscle power to cultivate their land. The Farm Mechanisation and Conservation Agriculture for Sustainable Intensification (FACASI) project aims to decrease the drudgery faced by farmers by improving their access to engine-powered machinery while minimising biomass trade-offs through Conservation Agriculture practices. A focus of the project is the development of business models for securing the provision of new technology as well as additional services. The project aims to overcome the low level of mechanisation in agriculture in SSA to improve farmers' productivity, yields and income.

Two-wheel tractor



Source: © Vergnani (2013)

FACASI is introducing 2WTs for land cultivation as well as off-farm activities. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and funded by the Australian International Food Security Centre. It started in March 2013, targeting eight locations in Ethiopia, Kenya, Tanzania and Zimbabwe.

Product: The project aims at creating a general awareness and understanding of technical innovations. Local importers, tractor manufacturers and dealers are approached by the project so they can act as multipliers and train local service providers. The target communities are those that are already engaged in CA within other projects. Through its broad approach, FACASI hopes to evaluate the current demand for the 2WT technology and develop suggestions for policy improvements and market features that would facilitate the further spreading of the technology. The main goal of FACASI is to develop innovative business models that ensure the effective distribution of new technologies. These include the provision of the 2WTs, but also additional machinery and tools used in CA. FACASI focusses more on distribution channels than on the technology itself.

Effects: CIMMYT estimates that 35,000 farms will benefit from the project over the course of four years. Using the 2WT for CA, farmers' incomes are

expected to increase by 50 per cent. When only used for off-field activities (transport, threshing, shelling), an increase in income of 20 per cent is expected. The whole region is projected to benefit from the mechanisation process. It is estimated that 360 new jobs will be generated due to the demand for local service providers. These providers are likely to experience a positive income effect as well. The overall economic boost of the project is estimated at US\$ 18.5 million. FACASI also aims to close the gender gap in farm power, as the 2WTs have proven to be steerable for women as well as men. The productivity gains with 2WTs are immense: some farmers reported they could cultivate up to eight times more land with a 2WT compared to working with oxen. Tractors are in some ways more reliable than draught animals, as the latter require additional care and are exposed to SSA's challenging disease environment.

Lessons learnt for mechanisation: Dr Frédéric Baudron from CIMMYT calls the 2WT a form of “smart mechanization” (Vergnani, 2013, p. 17), as it avoids many of the issues that led to the failure of the large tractor mechanisation strategies in the 1980s. The most significant change is the focus towards integrated business models, which, if designed well, will work independently to serve the demand for machines as well as services. Machines more adapted to the conditions in SSA can be imported from China and India. These machines are often also cheaper for African importers. From an agro-ecological point of view, the larger tractors caused degradation and soil erosion. This is avoided in FACASI, as the 2WTs are much lighter and are only used for CA, which relies on zero tillage. They are expected to cause less land consolidation and displacement – a problem usually associated with large tractors.

Recent policy changes in many sub-Saharan African countries support small-scale businesses. Since mechanisation heavily relies on new business models and the provision of additional services, such policies create an enabling environment for a new mechanisation strategy. Mechanisation with 2WTs in Bangladesh has shown that a model where some farmers become business providers for other farmers can work very effectively. FACASI wants to build upon these experiences.

Sources:

<http://www.facasi.act-africa.org>

Vergnani (2013)

Van Eerdewijk, Danielsen, Hailemariam, and Mukewa (2015)

3 Pedal Pump: Improved irrigation techniques can increase yields and reduce drudgery

Organisation: Improving irrigation systems can help improve yields immensely. Especially in areas with irregular and shortened rainfall periods, more and more farmers in SSA will depend on irrigation. Yet, fetching water is extremely arduous and time-consuming and puts extra pressure on women, as this task often falls into the female domain of the intra-household gender division of labour. The Swiss Concrete Pedal Pump, known as the PEP, is a foot pump that makes water sources for farmers more easily accessible. The Swiss Federal Office for Agriculture provided the financial and technical support for the development of the pump, and the Swiss NGO “Aqua Alimenta” has been the implementing force, in cooperation with other local NGOs. Its main beneficiaries are very poor rural households that contribute to financing the pump through the provision of construction materials and labour. The PEP is currently being used in 10 different countries, mainly by small-scale farmers. So far, more than 15,000 pedal pumps have been installed around the globe.

Product: The PEP allows farmers to tap into existing water sources, be it wells, rivers, lakes or even small ponds, in order to bring larger amounts of water closer to their plots and homes. Two advantages of the pump are its durability and ease of use, both resulting from the simple yet robust cement and wood construction. The pedalling is relatively simple, allowing everyone – men, women and children – to easily perform this task. Some farmers have even stated that the pedalling is fun for them. The pump is easy to assemble

and can be manufactured locally. In most instances, the PEP can be repaired by farmers themselves. From an ecological perspective, the pump is very valuable, as it is not dependent on fossil fuels and only draws relatively small amounts of water from existing sources.

Irrigation with the pedal pump



© Aqua Alimenta

Effects: The introduction of the pump not only increases farmers’ yields, it also lessens

the drudgery involved in irrigating the land by manual labour. Additionally, farmers save a lot of time and can engage in other income-generating activities. With human power of 50 watts, 60 litres of water can be extracted per minute from a depth of 3 metres through the pedal pump. This opens up opportunities for both intensification and expansion: farmers will either improve the quantity and quality of their production due to a more optimal water supply for the crops, or – where labour for subsequent farm tasks is available, they will extend the area they cultivate. The PEP can be a very good investment for farmers, as it is easy to purchase, with few risks involved. The promise of high effectiveness regarding yield increase offers an attractive cost-income ratio to farmers.

Lessons learnt for mechanisation: The PEP provides an example of a cheap and easy-to-use, low-intensity mechanisation tool for irrigation. Investment costs for the pump are relatively low and can be retrieved through the increase in yields and income, which makes it a viable option for many farmers in RW 3. It is important, however, that a network of local service providers exists to repair the pump in case of any greater damage. The supply of spare parts has to be ensured – be it by specialised repair services or by the local NGOs that Aqua Alimenta cooperates with in the field.

Sources:

<http://www.aqua-alimenta.ch>

Falcoz and Seurot (2009)

Aqua Alimenta (n.d.)

International Programme for Technology and Research in Irrigation and Drainage (2008)

Interview: Obrist 10/2015

4 AccessBank: “Agri-loan” takes irregular income and expenditure patterns of smallholders into account

Organisation: Due to the complex income structure of agricultural smallholders, financial products need to be specifically tailored to resulting seasonal fluctuations. Access Holding was established by LFS Financial Systems GmbH and operates ten specialised microfinance banks, six of them in SSA. These so-called AccessBanks have started to introduce a specific loan product for smallholder farmers in the region. The product was first piloted in Madagascar in 2011, has been offered in Tanzania since 2013, and is currently being introduced in Zambia (2015), with a feasibility study underway for Rwanda.

Product: According to AccessBank representatives, key to the success of the new product is its design. The agri-loan is an individual loan for less than EUR 10,000 and with a term of 12 months (or maximum 24 months for well-performing, repeat clients). Typically, livestock serves as collateral. The loan differs from standard microloans in the following ways:

- *Future cash-flow calculation:* AccessBank credit officers assess the specific cash-in and cash-out patterns of clients and elaborate an outlook on future cash flows, including the cost / income effects of the respective loan and monthly cash excesses / deficits.
- *Individually adapted repayment plans:* Grace periods may be given at any time during the loan period, which allows for taking gestation periods into account. Repayments are individually and seasonally adjusted to account for harvest and other income as well as important expenditures. Thereby, household and farm income and expenditures are taken into account, also considering, for example, school fees. Hence, repayment rates are pre-established and might differ from one month to another, responding to the economic profile of each client.
- *Credit assessment by sector specialists:* Loan officers receive training on agronomics and are provided with additional sector-specific information, such as local crop calendars.
- Accordingly, introducing and offering this agri-loan is costly for AccessBanks, but piloting and launching the product has been supported by international donors, including IFC and KfW.

The agri-loan is typically used as working capital for agricultural production, financing inputs and labour for the respective agricultural season. Sometimes animals and machines are acquired with the loans. In Zambia, the demand

for irrigation equipment is high. Responsible finance principles applied by AccessBanks ensure that investment projects are in line with the financial potential of applicants, that is, the bank may advise farmers to start with smaller or less costly machines to ensure repayment capacity is given.

Effects: Farmers' interest in this new product is reflected in the clearly expressed demand.

Since the introduction of the product, loan numbers and volumes have been increasing steadily. Until October 2015, nearly 5,000 loans were disbursed in Madagascar and Tanzania. The average disbursed amounts have been relatively stable at EUR 400 (Madagascar) and EUR 800 (Tanzania), respectively. Repayment rates have been excellent in both countries with longer experience, with portfolio at risk 90 days (PAR90) around 2 per cent for Madagascar, and under 1 per cent for Tanzania. More importantly, evidence shows that repayment rates for agricultural operations tend to be better than urban micro-loan portfolios (in the same institution). So far, no impact studies are available.

Lessons learnt for financing mechanisation: One of the central barriers to smallholder agricultural lending is the lack of bankable collateral (with land titles often not available), and the fact that the microfinance group approach does not fully suit the financing needs of agriculture: farmers in one locality mostly produce similar crops, face similar risks and have the same seasonality of incomes. Hence, the intra-group risk mitigation and mutual support used in microfinance peer groups does not work well. Furthermore, with increasing loan sizes, farmers tend to prefer individual loans. Dealing with high risk is another barrier to smallholder agricultural lending.

In the case of AccessBank, the farming-specific risk and the irregular cash flows are explicitly assessed and taken into account for the elaboration of individually adapted repayment plans. The financial institution also needs to invest in specific market intelligence and human resources with agronomic knowledge.

Sources:

IFC (2015)

Interview: Hédan, 12/2015

Direct promotion



© AccessBank

5 Graduation programme: Promoting farm and non-farm income-generating activities to reduce poverty and improve people's livelihoods

Context: Graduation programmes were originally developed by the Bangladesh Rural Advancement Committee, a non-profit organisation, and advanced further through the Consultative Group to Assist the Poor and the Ford Foundation. Working successfully in Latin America since 2011, the international development organisation Fundación Capital is expanding the graduation approach to Mozambique and Tanzania.

Product: The graduation programme intends to lift participants out of extreme poverty by providing them with productive assets and long-term training, allowing for lasting income improvements through small-scale economic or farming activities. The programme consists of five main parts, each of them relevant to guaranteeing sustainability:

1. granting of *consumption support* to help participants cover their daily spending;
2. encouragement of *saving* in formal financial institutions;
3. provision of *physical assets* for income-generating activities, for example business equipment or livestock;
4. skill *training* for business and financial knowledge and personal development;
5. *coaching* is done through permanent visits to the households to provide counselling regarding business management, and to give support and motivation.

The field managers assist the participants in developing long-term business plans and provide ongoing support and supervision throughout the entire programme. This ensures the success and the profitable operation of the new assets in the long run. Participants can generate more income through these new assets and are encouraged to save their money in formal financial institutions, allowing for new investments in the long term. Financial literacy training ensures participants' understanding of financial institutions and their own financial flows.

Effects: A recent study by Banerjee et al. (2015) on the effects of graduation programmes found that the programmes entail various positive effects on

participating households. Results of six randomised control trials show that in most instances, key factors such as per capita consumption, household food security and asset-holding increase significantly in comparison to the respective control groups. These positive effects prevail even one year after completion of the programme, whereas other initial effects such as improvement of health

and women's empowerment do not show similar long-term effects. Khalid El Harizi at IFAD concludes that graduation programmes do have a positive effect on people's livelihoods, but so far they cannot lift people out of chronic poverty. The programmes seem most beneficial for people living just below the poverty line, and less so for the chronically poor.

Lessons learnt for financing mechanisation: Although, as of yet, the programme's use for agricultural purposes is not common, the graduation programme has the potential to equip farmers with simple farming tools or livestock to boost production and farming incomes. The target group consists of poorer households typical of RWs 3 and 4, which often do not have adequate financial means to purchase any assets. Most importantly, graduation programmes teach us that long-term training and support are crucial factors for ensuring profitability and for lifting people out of poverty.

Fundación Capital considers one of the most important success factors to be close cooperation with national governments. Programmes are implemented by governments and owned by them: this allows implementation on a greater scale and complement programmes that already exist within the country. Another central factor is the use of innovative channels to reach participants. Digital solutions such as an app and an e-learning platform make the programme more cost-efficient: they provide participants with knowledge and can be used by field managers and other staff to exchange best practices and experiences.

Sources:

<http://www.fundacioncapital.org>

Banerjee et al. (2015)

El Harizi (mimeo)

Produciendo por Mi Futuro (Producing for My Future) coach providing training via tablets in Colombia



© Fundación Capital

6 CUMA: Benin farmers show how mechanisation can be financed in the absence of financial services through a cooperative scheme

Context: Most local farmers cannot afford to purchase farm machinery individually, so shared ownership is one of the few options for them to realise mechanisation. Modelled after the French system of the *Coopérative d'utilisation de matériel agricole* (Cuma – cooperative for agricultural machinery use), French Cumas have supported the foundation of a cooperative system for the purchase and use of agricultural machinery in Benin.

Cuma is based on voluntary membership of small farmer groups that wish to invest in machinery. Group members coordinate their farming tasks and exchange skills and best practices. Since 1997, around 120 Cuma organisations have been established in Benin, with around 1,200 members today. Depending on the major crops grown in a particular region or farmers' group, some Cuma are investing in tractors, ploughs and trailers, whereas others invest in processing equipment such as cassava graters or palm nut oil machines.

Product: Within a Cuma, farmers voluntarily join together under a set of rules, on the basis of geographic proximity, affinity among members and common sense of commitment. Each member is obliged to contribute financially to the Cuma, while shares are proportionate to the size of land a farmer wishes to work on with the machinery in question. Thus, membership and machinery access become feasible for smaller farmers, while at the same time also offering viable opportunities for medium-scale farmers.

Yet, in Benin, the purchase of mechanisation equipment is complex and difficult. In the absence of access to credit, farmers save up money within the group – a long process that can take several years, increasing instability through the danger of dropouts. To add to this, the private sector has lagged behind in providing adequate and affordable machinery supply, so most Cuma are dependent on intermediaries such as government programmes or NGOs to acquire or import the necessary machinery. Once the machinery is purchased, farmers have to establish a financial buffer for cases of damage, or when additional equipment is needed.

Within the Cuma network, trainings in machinery use and maintenance and in the proper use of the plough are offered in order to minimise soil degradation

through misuse and to extend the machinery's longevity. This also raises awareness in farmers that the higher costs of machinery ownership within the Cuma are justified, compared to private service providers who are often not properly trained in ploughing techniques.

Effects: Cuma farmers who use a tractor are predominantly active in cotton and corn crops. For them, the tractor allows for better timeliness in planting and an estimated expansion of the total area cultivated to 3.5 times of what they were farming before. The farmers involved specialise their production and focus on market orientation. With a tractor and plough, only certain tasks in the growing cycle are mechanised, so more manual labour is needed for subsequent tasks in planting, weeding and harvesting. Cuma farmers mainly hire external labour to cope with the surface increase in cultivation, turning their family farm into a family business and providing rural employment opportunities. Most farmers reported an increase in income, allowing for further investments in the farm, but also in livelihood improvements through education and health services and access to food. Yet, mechanisation within the Cuma is not limited to tractor use. The first cooperative was engaged in ploughing and transport activities in the north. Nowadays, women-led Cumas in the south are developing activities for primary transformation of cassava with graters and processing of palm kernel with presses and crushers.

Lessons learnt for financing mechanisation: Cumas provide important lessons for machinery financing and ownership. A Cuma results from a deep farmer-endogenous dynamic that leads to the construction of cooperatives that are genuinely crafted by their members. This organisational structure makes it possible for farmers to finance even higher-intensity mechanisation such as tractors while relying on savings only. Yet, as this process takes several years, during which members might drop out or have other financial needs, access to credit would facilitate the process enormously. The Cuma example also shows that shared ownership can work for farm machinery but needs elaborate rules and planning. Training for mechanics and drivers, but also for managers at local cooperative levels, need to be provided

Presentation of a tractor



Source: © Cuma Benin (n.d.)

by the network to guarantee profitability of mechanisation – a learning that goes beyond shared ownership, but that is certainly applicable to all mechanisation endeavours.

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<http://www.cumabenin.com>

Balse et al. (2015)

Herbel, Ourabah Haddad, and Villarreal (2015)

7 NWK Agri-Services: Agribusiness companies can facilitate sustainable mechanisation

Organisation: NWK Agri-Services (NWK AS) is an agribusiness company located in Zambia working with more than 100,000 farmers through different comprehensive schemes that circumvent common constraints in SSA's agricultural sector. NWK AS mainly offers advanced input financing, but emergent farmers can also participate in a mechanisation scheme. Additionally, the company provides extensive agronomic and business training, storage and supply of high-quality inputs to participating farmers, and guarantees market access. The company thus avoids infrastructural and market constraints that many farmers face in SSA and offers access to finance to an otherwise underserved group.

Innovation: To participate in the mechanisation scheme, emergent farmers have to pay 10 per cent of the investment costs upfront and have to show that they have a minimum of 45 ha of cultivatable land. The mechanisation package includes a tractor plus all necessary additional equipment, such as rippers, seeders and trailers – at an overall investment cost of US\$ 40,000–45,000. In collaborating with three commercial banks, NWK AS acts as an intermediary between banks and farmers and plans to finance farmers directly, acting as a financial institution of its own. The company negotiates loan conditions with the banks on the farmers' behalf, targeting a loan tenure of four to six years for machinery, with interest rates of 20 per cent (partly due to the high volatility of the Zambian currency). NWK AS pays the monthly rates to the bank on behalf of the farmers. The farmers pay NWK AS when their cash flow allows them to, usually at the end of the season. This helps farmers to bridge the time until harvest incomes arrive, and it avoids delays or defaults in repayment, which often arise when the farmers have to pay monthly rates to the banks directly. Throughout the

entire credit period, farmers are obliged to sell all their produce to NWK AS – since loan instalments are deducted from the farmers' sales revenues – and purchase all necessary inputs at regular market rates through them. All mechanised farmers also receive training on machinery maintenance and have access to on-site repair services in case of greater damage. Throughout their cooperation with the farmers, NWK AS monitors and supervises their progress and performance regularly. The company plans to add 50 new farmers to their mechanisation scheme each year.

Each emergent farmer with a tractor in the NWK programme is obliged to cultivate a minimum of 45 ha of land during the growing period. Empirics show that emergent farmers with two tractors are able to supply 800 peripheral farmers with services. Peripheral farmers can hence cultivate land they otherwise would have had to neglect due to the lack of farm power. That way, emergent farmers use their tractors most efficiently to increase and diversify their incomes. This makes loan repayment easier. Often, service providers also get paid in cotton from the smaller farmers.

NWK AS signs input financing and offtaker contracts on a yearly basis and tries to offer competitive prices in comparison with other dealers in order to keep farmers in their scheme. All farmers – peripheral as well as emergent farmers – are required to cultivate a combination of different crops on their land, including cotton. This diversification enhances farmers' resilience to different shocks and preserves soil fertility. NWK AS also offers mobile phone banking to farmers and has helped to finance 20,000 phones. Payments between farmers and NWK AS can be made via mobile phones, lowering transaction costs. Weather and crop insurance are also available for farmers.

Effects: By using the different schemes offered by NWK AS, farmers can improve their livelihoods mainly through increases in income. Diversification and stability of income streams make them less vulnerable to shocks and increases their food security. Extensive training and mechanisation allow farmers to cultivate their land to its maximum capacity and increase yields. The increased income security is expected to have a positive impact on education, since farmers can now afford school fees for their children.

The mechanisation of land preparation (ripping) has been shown to have major effects on production and income, as well as on farmers' time and the size of cultivated land (see Table 8).

	Previous	After	% change
Average planted (ha) (farmers)	3.87	6.26	62
Land preparation (days)	97.5	4.5	-95
Maize preparation (bags)	200	357	79
Cotton production (bales)	52	74	42
Cotton yields (kg/ha)	700	1,000	43
Farmer incomes per annum (\$)	6,331	12,998	105
Total income TSPs (\$)	4,073	13,550	233
Source: NWK Agri-Services (n.d.), with own calculations of % change			

Lessons learnt for financing mechanisation: In order to guarantee steady flows of quality agricultural products to the company, NWK AS has found ways to adapt to some of the more important constraints in Zambian agriculture. Acting as an intermediary between farmers and banks, agricultural markets and machinery suppliers, NWK AS provides a variety of services to farmers in addition to mechanisation: access to financial services, training and information, machinery and market linkages. To face the lack of formal land titles, the company shows flexibility in accepting informal land titles and usage rights as a form of collateral. When dealing with banks, NWK AS offers the necessary securities to the financial institution, if farmers themselves are not able to provide, and negotiates favourable and adapted loan repayment schemes.

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NWK Agri-Services (mimeo)

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Interviews: Knierim, 11/2015; Bertenbreiter, 10/2015; Peltzer, 09/2015

8 Hello Tractor: The use of new technologies for innovative tractor-hiring services in Nigeria

Organisation: Hello Tractor is a social enterprise working in Nigeria with the aim of improving farmers' access to mechanisation through innovative tractor-hiring services. Since many farmers lack collateral for investments in machinery, hiring services can offer an alternative that allows farmers to increase their productivity, yields and income while avoiding high financial burdens and risks. Hello Tractor works on facilitating access to hire services for smallholders.

Product: Hello Tractor has equipped some farmers with tractors and established a so-called Smart Tractor network. Other farmers can hire these tractors via SMS. The unique feature of the programme's tractors is their GPS antennae. These allow Hello Tractor to track the usage, location and uptake of the tractors and assures tractor owners about where their tractors are at all times. An additional step in the payment chain provides securities for farmers and service providers: the smallholders pay Hello Tractor for the booked services upfront with mobile money. As soon as a particular farm task is completed, the respective amount of money is forwarded to the service provider. The comprehensive booking system allows farmers to request a service, schedule the exact date and time, as well as pay – all through one system.

The tractors come with various equipment parts, so they can be used for different crops, different production cycles and different parts of the value chain. This makes it possible for tractor owners to offer their services year-round and make the most effective use of their investment. Hello Tractor is aware of the fact that the tractors require proper maintenance services and has incorporated this into their strategy. Technicians are trained how to repair tractors, and the owners are supplied with all necessary spare parts. To make repair even more feasible for tractor owners, Hello Tractor arranges for on-site repairs, so they do not incur additional costs.

Female tractor owner



Source: © Changemakers (n.d.)

Effects: For the tractor-owning farmers, the Smart Tractor is a long-term investment. They will be able to pay off the necessary credit with the money they earn when providing services for other farmers. Tractor owners who work as service providers can earn five times more than the average daily wage rate because the market is underserved. Since the organisation started its work in 2014, participating farmers have increased their yields by 200 per cent. The tractor can cultivate land 40 times faster than with manual labour, saving time that farmers can use for other income-generating activities. Hello Tractor has estimated that they can reach roughly 20,450 farmers through their existing networks in the upcoming years.

The programme is especially beneficial for women, who are often discriminated against in agriculture. As many male farmers would initially not choose women to cultivate their fields with a tractor, Hello Tractor's anonymous booking system allows women to own tractors and be booked to service fields for other farmers, building businesses as service providers.

Lessons learnt for mechanisation: Hello Tractor is another example of a company stepping in as an intermediary to overcome agriculture-specific barriers in SSA. Bulk purchasing allows the company and farmers to save money compared to single purchases. The tracking of tractors prevents misuse and allows for a more-efficient allocation of services, and communicational constraints are overcome through the mobile booking system. The extra step in the payment chain via Hello Tractor reduces financial insecurities by guaranteeing payment to the service providers and setting incentives for timely service delivery. The impact is especially positive for women, as they benefit from the system's anonymity. Hello Tractor has thus developed a model through which tractor-hiring services can work more effectively and safely.

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<http://www.hellotractor.com>

Hello Tractor (n.d.)

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9 DCFU leasing: Agricultural leasing products can provide farmers who lack collateral with a chance to mechanise their production

Context: Leasing can solve farmers' difficult access to finance, as the leased equipment itself can serve as collateral. The Development Finance Company of Uganda (DFCU) launched leasing operations in Uganda in 1995 and mainly serves SMEs. Although it has a commercial orientation, it takes a strong stance for the promotion of development with its mission statement "to maximise shareholder growth while maintaining and building up its capacity to support development-related activities" (Kisaame, 2003, p. 3). In 2003, rural financing made up 47 per cent of DFCU's total business volume. Later portfolio analysis showed that 5 per cent of the financial institutions' portfolio was dedicated to the agricultural sector; 20 per cent of the agricultural finance activities are done as leasing. Overall, DFCU's leasing business grew by 32 per cent in 2010 and only 1 per cent of the assets were non-performing, that is, in default.

Product: DFCU started its work in the agricultural sector in 2000 in three rural cities, promoted by USAID. Since then, the bank has become more independent and is providing leasing products in various parts of the country. The average size of a lease is US\$ 35,000, and the overall range is US\$ 25,000–250,000. In a typical leasing case, clients have to provide roughly 40 per cent of the finance for the purchase themselves. Depending on the case, this ratio may vary from 10 to 50 per cent. During the time of the lease, typically ranging from two to five years, DFCU keeps complete ownership of the asset. When the leasing period adjourns, the asset is sold to the client (lease purchase) or to somebody else.

Clients have to present auditing reports and business plans to be considered as a lessee, based on which DFCU evaluates income sources and cash flow. Clients choose the machinery themselves and submit a report about its condition to DFCU. Sixty per cent of the leasing equipment is already used; this saves a lot of money for both clients and DFCU. In the agricultural sector, most of the leasing applies to machinery, such as tractors, harvesters and processing equipment. However, DFCU takes care to only finance such types of machinery that have a secondary market, that is, they can be resold in case of client default. During the entire leasing period, the client must provide insurance for the asset. DFCU has its own insurance unit, so clients can purchase their insurance from the same provider and, if needed,

include it in the lease payments. Throughout the leasing period, DFCU staff members regularly audit the leased machinery in field visits, with a special focus on clients who are overdue on their payments. They also apply new technologies, for example GPS tracking devices, to some of their machinery to be able to monitor their clients more efficiently.

Effects: Overall, farmers can benefit from leasing a machine, as they can generate higher income without having to provide collateral. Examples in the processing stage are stainless steel cans for dairy farmers, which allow them to better store their milk, or mills to grind grain more efficiently. In production, bigger machinery such as tractors can improve the harvest immensely.

Typically, the part of the value chain that can benefit a lot by leasing is the transport sector, as leasing is often done for bigger, more expensive machinery. New transport can allow farmers to access new markets. Due to a faster connection to markets, products also retain better quality, hence higher prices can be achieved and food loss reduced considerably.

Lessons learnt for financing mechanisation: DFCU's leasing products cater to the needs of clients who are too big for MFIs but who do not meet the requirements in terms of collateral from commercial banks. DFCU is attractive for SMEs due to long leasing periods. Interest rates are similar to those offered by commercial banks, but flexible repayment plans and using the purchased asset as collateral make this type of financial service much more feasible for resource-poor clients. The company has made an effort to gather relevant knowledge on agriculture and technology to provide needs-based and tailored products. The average processing time for deals is two weeks, which allows for equipment use in the same season – an aspect of high importance in agriculture.

Much attention was given to DFCU for its SME leasing activities: in 2002, 16 per cent of the leasing was for agricultural equipment. However, in 2011, only 8 per cent of the leasing portfolio targeted the agricultural sector, accounting for US\$ 2.2 million and an average lease amount of US\$ 115,000. Considering the large amount of donor support DFCU has received, this is not much, and average lease amounts indicate that it is rather medium-sized enterprises that make use of this financial product. Given the high prepayment requirement (up to 50 per cent, depending on the client's risk profile), such a product may only be attractive to highly profitable or liquid businesses rather than those of medium size.

The small agricultural portfolio share is explained by the fact that in Uganda – as in many other sub-Saharan African countries – leasing is subject to double taxation: each time a piece of equipment changes ownership (i.e. from the supplier to the lessor and again from the lessor the lessee), VAT applies. Therefore, leasing becomes very expensive and is, hence, not suitable for low-margin business environments such as agriculture. Next to such an enabling environment, product features still need to be tailored to the agricultural sector. IFC has summarised well the lessons learnt with regard to agricultural leasing in the following quote:

The leasing companies that are successful in the agriculture sector report that the key to their success is good knowledge of the agricultural sector, dedicated resources to serve agricultural producers in proximity to them, flexibility in leasing payments to match farmers' cash flow, and good credit risk assessment systems adapted to the agriculture sector. (IFC, 2012, p. 46)

Sources:

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10 **Kafo Jiginew: A credit cooperative in Mali offers a special-designed agricultural equipment loan to low-income clients**

Context: Kafo Jiginew is a credit cooperative in the south of Mali that was created as one of the first of its kind by cotton farmers in 1987. The rationale was to establish a bank for farmers that would help manage

Clients of Kafo Jiginew



Source: © Kafo Jiginew (n.d.)

different financial management needs, including savings, credit and, by now, also insurance products. Today, the MFI serves close to 60,000 clients, still strongly focussing on farmers and rural craftsmen. As of 2013, its total portfolio was US\$ 50 million, and the average loan size slightly above US\$ 800.

Product: Kafo Jiginew offers a loan called “*Crédit d’équipement*”, which was created for investments into farm assets such as machines ranging from motorised pumps to drought animals and four-wheel tractors. The average loan amount is US\$ 415 with a low interest of 1.5 per cent, and the tenure may be up to five years (for tractors) – posing an exception to other typical loan products the MFI offers. For this product, Kafo Jiginew has acquired refinancing from international donors, including the European Investment Bank.

The innovativeness of this equipment loan lies in its characteristics in terms of loan use and the conditions an interested client needs to fulfil. First, a client has to become a member of the local cooperative for owners of motorised machines. The cooperative then (if members agree) acts as a guarantor for this specific client. Furthermore, the person must be an existing client with a good credit history. Second, the MFI checks if the client owns a minimum amount of land (15 ha), if the household has a minimum of 10 adult persons who can work on the field, and researches the production levels of the past three years. In addition, at least one household member must be able to read and write. At the same time, the client has to lay out in detail how she plans to use the new investment.

Once all requirements are fulfilled and the loan is granted, the money is not transferred to the farmer. Instead, the funds are directly transferred to the machine provider who has agreed to offer machines to Kafo Jiginew at a reduced price. Once the delivery of the machines to the client is confirmed, the loan is marked as active.

Effects: Taking up equipment loans has resulted in an increase in cultivated land by members of the cooperative. According to reports by Kafo Jiginew, this has also increased their income levels considerably. At the same time, many clients have rented out their machine to other families for a fee or have used it for other income-generating purposes (e.g. transport). Knowing that access to a machine bears the risk of specialisation, clients were advised to keep their crops diversified, including subsistence crops, such as vegetable gardens.

Lessons learnt for financing mechanisation: The loan portfolio of the equipment loans is healthy. Although demand is high, the institution declines many loan applications. According to Kafo Jiginew, one of the most important aspects of this loan is understanding if a real need for such an investment in machinery exists on the side of the client. In addition, there is a close relationship between the cooperative and local producer organisations, partly reflected in governing positions of staff members in a producer organisation. This helps to know and understand clients' needs as well as risks.

Over time, Kafo Jiginew has been able to create a highly specific loan product with a high level of built-in risk-mitigation factors prior to loan payout. At the same time, the client assessment is highly forward-looking in an attempts to understand and anticipate if a client has the right preconditions for making the most of this expensive investment.

An important learning on food security is included as well: because the MFI knows that the machine investment is likely to result in producing cash crops, that more land will be cultivated for this and that part of the income will be reserved for the loan instalments, borrowers are requested to keep a certain minimum of food crops to secure their subsistence.

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