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Conceptualising Farming Systems for Agricultural Development Research: Cases from Eastern and Southern Africa

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Abstract

In the context of broad scale system changes (e.g. climate change) and the prioritisation of impact-at-scale development, there is a particular need for farming systems research (FSR) to improve our understanding of the links between systems at multiple scales. Drawing on three empirical case studies of large-scale agricultural interventions in eastern and southern Africa, we highlight problems that arise from conceiving and justifying interventions on the basis of the simple aggregation of farms into large collective systems. We review changes in the approach and concepts of FSR and point to the value of farming systems concepts that go beyond these aggregations, and find ways to capture the multi-level system dynamics that link on-farm decision making to broader political, social, and environmental changes. Recent attempts at more accurately conceptualising the domain of FSR, and drawing distinctions between 'farms', 'systems', and 'systems of farming', represent a useful contribution to such work.

Introduction

In the face of multifaceted uncertainties and the complex challenges of adaptation in Africa's agricultural sector, the use of a 'systems' approach is increasingly favoured across the interlinked epistemic communities of agricultural research and policy (Collinson, 1987, Dixon, 2000, Darnhofer et al., 2012a). Such an approach recognises the contextual and dynamic nature of smallholder agricultural production and enables analysis of both biophysical and human processes that span temporal and spatial scales. Particularly since the 1980s, agricultural researchers have recognised the ways that interconnected and historically embedded social, economic, cultural, political and ecological processes interact to shape the dynamic contexts within which farmers make decisions (Collinson, 2000).

'Farming systems research' (FSR), the once proudly adopted label of a new and emerging discipline, was closely linked with developments in participatory research and the 'farmer first' movement (Chambers and Jiggins, 1987, Chambers et al., 1990), with obvious complementarities between the conceptualisation of multifaceted and localised systems, and the insights that might be gained from drawing on the knowledge of the farmers that experience this complexity first-hand. Whilst participation was once a central tenet of FSR, as the field has grown, approaches and applications within it have inevitably diversified. As a result, the FSR label itself is increasingly seen as a catch-all concept (Sands, 1986, Noe and Alrøe, 2012, Leon-Velargde et al., 2008, Hart, 2000), inclusive not only of investigations in to farm-scale processes, but of landscape scale modelling (Feola et al., 2012) and economic analyses of data from surveys of large populations of farms of similar resources and activities (Dixon et al., 2001).

In response to this divergence, recent discussions over the appropriateness and application of the central ‘farming systems’ concept, and attempts to rethink it (Giller, 2013, Sumberg et al., 2013) are overdue. Dixon’s (2001) recognition of individual ‘farm systems’ within broader ‘farming systems’, Giller’s (2013) acknowledgement of the diversity, interactions, and interdependencies of farm systems (i.e. the heterogeneity of Dixon’s ‘farming system’) and Sumberg et al.’s (2013) further distinction of a ‘system of farming’, to represent the systematic nature of on-farm decision-making, are all important contributions.

Drawing on these concepts, this paper presents a set of theoretically-grounded analyses of case studies of agricultural technology and research-based interventions in eastern and southern Africa, in which we make a distinction between the assumptions that underpin these large-scale system interventions and the farm system-level constraints and dynamics that determine the way that these interventions are experienced.

In reflecting on these cases and the recent history of development and disciplinary diversity within FSR, we recognise the value of a systems approach to understanding the political, social, environmental, and economic dynamics between, and beyond diverse and interacting farm systems. The implications of this are drawn out in the discussion, which suggests (in accordance with Giller) that a multi-level concept of farming systems, and (in accordance with Sumberg et al.) a focus on the systematic nature of decision-making, can offer important insights into, and even a means of re-negotiating, pathways of agricultural development.

Background

A conceptualisation of farming as a bounded system in which multifaceted and historically-embedded component parts – social, political, ecological, climatic, cultural, and economic processes – interact in dynamic ways, and a focus on these multiple system interactions, is at the core of an increasingly diverse field of agronomic research (Byerlee et al., 1982, Collinson, 1987, Collinson, 2000, Darnhofer et al., 2011, DeWalt, 1985, Dixon, 2000, Gibbon, 2012, Maxwell, 1986, Quiroz et al., 2000, Ruthenberg, 1980). FSR became popularised as an approach to understanding the challenges of translating a green revolution of agricultural modernisation into the heterogeneous production environments of Africa and Latin America in the late 1970s (Collinson, 2000, Norman, 1995). The institutions of the Consultative Group on International Agricultural Research (CGIAR), primarily concerned with identifying barriers to the adoption of new technologies and techniques, began to acknowledge the ways in which context-specific access to agricultural inputs and output markets and the geographic distribution of poor soils acted to constraint the choices of smallholder farmers (Norman, 1995, Norman, 1978).

In collaboration with national agricultural research centres, particularly in southern and eastern Africa and Latin America, new research programmes within the CGIAR institutions emerged. In accordance with the participatory turn of the 1980s, these involved interdisciplinary teams of crop breeders and social scientists often combining economic analysis of farm/household surveys with participatory evaluations of new technologies (Norman, 1978, Norman, 1995, Collinson, 2000, Cleveland and Soleri, 2002). Sands (1986) explains that participatory research and being 'farmer-oriented' and 'on-farm research' were key components of FSR as it was 'originally conceived'. The late 1980s saw a broadening out of the participatory agenda, with tools such as Participatory Rural Appraisal (PRA) being advanced as a way of engaging with farmer-defined challenges and livelihood options, as opposed to restricting participation to a technical consultation over end products (as in participatory varietal selection) (Chambers, 1992, Chambers et al., 1990).

However, in spite of this movement, international agricultural research and development programmes, have struggled, in a similar way to that of national agricultural policy makers, to reconcile their recognition of heterogeneity and complex systems, with the reductionist inclinations that come with a focus on large scale, or even global priorities (Dalrymple, 2008, Gardner and Lesser, 2003, Brooks, 2011). Arguably the growing prioritisation of climate change agendas with agricultural research and development, and the dominance of global climate modelling in framing these agendas (Whitfield, 2014), has contributed to a movement away from farming systems being about local complexity towards a conceptualisation of, and focus on, regional/landscape scale systems.

Whilst the commitment to FSR within international (and African in particular) agronomy has strengthened since its 1970s origins, its application has significantly diversified. In its contemporary guise, FSR is no longer restricted to having an objective of addressing adoption constraints or even a focus on participatory and on-farm research, but it encompasses inquiry into the infrastructures, processes and/or functionality of farming, motivated by a range of objectives, utilising a range of methods, and this diversification is underpinned by a growing range of conceptualisations of the actors, boundaries, scales, and mechanisms of the 'farming system' (Sands, 1986, Darnhofer et al., 2012b, Collinson, 2000).

A search term-based review of papers published in the journal Agricultural Systems since 2000[1] indicates that 192 papers are self-defined as farming systems research and, of these, 109 adopt a systems modelling approach, 94 involve some kind of econometric systems analysis, and 64 are based on participatory research. Modelling itself represents a diverse method of inquiry inclusive of the use of complex quantitative parameterisations of system components and interactions as well as more qualitative descriptors of systemic processes, and there has been a growth in the use of models as tools for participatory research, scenario development, and negotiated decision making (Whitfield and Reed, 2012). Within these studies, systems are defined in a variety of ways, with at least 14 papers explicitly addressing 'smallholder farming systems' and 8 targeting 'maize, rice or wheat farming systems' specifically. A range of other systems terminology, often not

[1] As of May 2014

explicitly distinguished from ‘farming systems’ is also evident, including ‘cropping systems’, ‘innovation systems’, ‘agro-ecological systems’, and more.

In interpreting complex systems, the disciplinary diversity of the field may represent a strength, however the broadening array of system concepts that underpin these endeavours creates challenges for interpreting and integrating a growing body of evidence. Despite Deborah Sands’ (1986) warning about the ambiguity associated with the concepts and approaches of FSR, critical engagement with the concept of farming systems has, until recently, inadequately addressed the divergence of ‘farming systems’ definitions (Giller, 2013), which has largely taken place under the radar of academic acknowledgement. Despite the fact that purposeful communities of FSR have formed (such as the International Farming Systems Association) they operate without a clearly defined concept of what constitutes a farming system and what FSR is and what it is not, with the result that they have little basis for cross referencing and the building of collective evidence.

Early definitions of farming systems, particularly those concerned with its application in relation to African smallholdings, emphasised a focus on the individual farm or household as the primary unit of study. Shaner et al (1982) defined the farming system as:

> ‘a unique and reasonably stable arrangement of farming enterprises that the household manages according to well-defined practices in response to physical, biological and socio-economic environments and in accordance with the household's goals, preferences and resources. These factors combine to

> influence output and production methods. More commonality is found within the system than between systems. The farming system is part of larger systems - e.g., the local community - and can be divided into subsystems - e.g., cropping systems. Central to the system is the farmer himself' (p.37)

This corresponded closely with the participatory movement of the time, positioning the farmer as the expert within their own farming system, which itself has an internal uniqueness that distinguishes it from the broader systems of the local community. This contrasts with a definition proposed by the FAO, almost two decades later in 2001, one which represents a significant and widely cited and adopted attempt to place new boundaries around the farming systems concept, which defined the system as.:

> '…a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households.' (Dixon et al., 2001: 13)

This represented a distinct attempt to attach the concept to a landscape/regional scale of operation delineated through a categorisation of households. Within this definition there is a clear framing of the concept of farming systems to conform to research agendas that aim to develop appropriate technologies at scale. But implicit within the aggregating across 'farm systems' that is central to this definition, is an erosion of emphasis on the complex dynamics that characterise these small scale systems, and that was central to the early FSR concepts and participatory movement. Giller's (2013) recent critique of the FAO definition takes issue with its implicit homogenisation of farm-level dynamics. Building on the hierarchy approaches evident within much earlier FSR (Ruthenberg, 1980, Fresco and Westphal, 1988), he argues for a similar nested concept of 'farm systems', as decision making units that capture households, resources and land management practices, within broader 'farming systems', but argues that the diverse dynamics, needs, opportunities, and levels of connectedness of these smaller unit systems, must not be overlooked:

> 'A farming system is defined as a population of individual farm systems that may have widely differing resource bases, enterprise patterns, household livelihoods and constraints. Rather than seeing a farming system as a single recommendation domain, we could state that the farm systems exhibit varying degrees of interdependency and interact in use of common property resources. The diversity of farm enterprises requires that development strategies, interventions and policies need to be tailored to their different needs and opportunities.' (Giller, 2013: 3)

This re-emphasis on the complex dynamics of the farm system, the domain in which the farmer is expert, has important implications for the re-elevation of participatory involvement within international agronomy and policy making. To further add to this taxonomy of concepts, Sumberg et al. (2013) suggest that, within their respective systems, farmers might adopt their own 'system of farming; a more or less systematic and consistent way of going about the business of farming', within which research-based interventions, technologies, and policies 'from above' might be differently appropriate. Such 'systems of farming' may be shaped by the dynamics of the farm system, but are not determined by them and, as such, reductionist assumptions about farmer decision-making are problematic.

In this paper, we think critically about the farm and farming systems concepts through their application to the analysis of several case studies of smallholder agriculture in eastern and southern Africa. These are cases of which the authors have experience through doctoral and post-doctoral research and more empirical presentations of the associated research projects, and their methods, is described and in press elsewhere (Whitfield, 2014, Whitfield and Kristjanson, 2014, Dixon et al., 2014, Ngoma et al., 2014). Here the aim is to draw lessons from the application of a common conceptual framework across these diverse cases. The cases differently consider technology developments (genetically-modified, water efficient maize); land management strategies (conservation agriculture); and extension services and input subsidies, by a variety of international agricultural research institutions, governments, non-governmental organisations and private sector actors, within smallholder farming systems. In each case we attempt to critically consider the 'from above' conceptualisation, framing and motivation behind these 'interventions' in relation to the 'from below' experience of 'farm systems' of smallholders. These case studies are summarised in Table 1.

Case Studies

The case studies describe differences between the design of impact-at-scale interventions, which inevitably involve aggregated assumptions about a constructed farming system of 'broadly similar' farms (along the lines of Dixon's et al.'s conceptualisation), and the context-specificity of the constraints and experienced realities of farmers. They illustrate the potential problem of system assumptions that are based on the aggregation of farm scale challenges and demonstrate the diverse and interacting nature of farms (as per the definition of Giller). We look at evidence from these cases that suggest that multi-level dynamics, within, between and beyond the farm (as per the conceptualisation of Shaner et al.) act to shape systematic decision making and multiple rationalities (as per the 'systems of farming' concept of Sumberg et al.), and argue for the importance of FSR that can interrogate these complex dynamics.

The 'Water Efficient Maize for Africa' Project in Kenya

In 2007 the Water Efficient Maize for Africa (WEMA) project, was established through a grant made by the Bill and Melinda Gates Foundation (BMGF) to the African Agricultural Technology Foundation (AATF). The project brings the International Maize and Wheat Improvement Centre (CIMMYT) into partnership with Monsanto PLC, an international agro-chemicals company, in order to improve CIMMYT drought tolerant germplasm through genetic modification (e.g. the insertion of a 'cold shock' protein gene sequence, the isolation and insertion of which Monsanto hold a number of patents) and modern breeding techniques (e.g. marker assisted breeding), and disseminate it to smallholder maize farmers in five countries: Kenya, Mozambique, South Africa, Tanzania, and Uganda. AATF has drawn up a royalty-free sub-licencing agreement, that means that WEMA seed can eventually be marketed to smallholders at a cost no greater than conventional market hybrids.

In Kenya, the commercial release of WEMA's first non-transgenic hybrids, developed in accordance with CIMMYT's agro-ecological zonation, for dry mid-altitude and moist-transitional regions, is due in 2014, but the prospects for release of transgenic varieties remains uncertain, with national biosafety regulatory protocols placing restrictions on the trialling of these varieties and the necessary environmental release permissions needed for on-farm trialling not yet established.

The story of agricultural change advanced within the official communications and reports of the WEMA product (produced by AATF) is of a 'pro-poor' technological solution to problems of poverty and food insecurity within rain-fed smallholder maize farming that are largely ecologically and climatically driven, as indicated in this WEMA policy brief:

> 'Persistent incidences of drought in Kenya have continued to threaten the food security situation and subjected millions of Kenyans to starvation… Modern biotechnology provides a major opportunity to address perpetual maize shortages that are now being compounded by new threats triggered by climate change… WEMA was launched as a demand driven technological innovation designed to strengthen the resilience and adaptive capacity of maize farmers to cope with drought… Stable and reliable yields will revitalize and build the confidence of farmers in maize production.'

('Reducing maize insecurity in Kenya: the WEMA project'; Water Efficient Maize for Africa Project (WEMA) Policy Brief, November 2010)

The constructed farming system that is targeted in WEMA is delineated predominantly on the basis of two dimensions – the size of farms (i.e. smallholdings), the dominant crop type (i.e. maize) – with further delineation of crop products on the basis of maize agro-ecological zonation. Improving tolerance to drought undoubtedly responds to an experienced challenge and self-defined need of small scale farmers in semi-arid agro-ecosystems in Kenya. However, assumptions about the scale-neutrality of the WEMA technology (such that the commercialisation of the seed will not unfairly advantage the wealthy large scale farmer) and rhetoric about the 'one size fits all' nature of the technology contain inherent assumptions about the homogenous nature of its target farming systems.

Perhaps because reflective of the involvement of the private sector and new philanthropic organisations: the WEMA narrative has a particular business-mindedness, in which the technology is presented as an economically rational and efficient intervention centred on achieving ambitious targets within regulatory environments that allow for rapid spill-over of the product over large scales.

There is an obvious trade-off between the practicalities of targeting varieties for large-scale impact and responding to the local conditions and requirements of farms. Even within a system whereby breeding is scaled down and gradually decentralised (with opportunities for participatory varietal selection) from more generic trial sites, as is done within CIMMYT breeding, performance based selections of germplasm take place at early stages under generic conditions, and the assumptions that underpin these selections act to frame breeding outputs. The trialling of transgenic varieties is even more limited, due to the biosafety requirements at trial sites. WEMA currently has permission for just one trial site within Kenya, at the Kiboko research station. The limitations of trialling within just one location mean that agro-ecological conditions for the trial cannot be varied and a fairly arbitrary decision has to be made about the generic conditions under which trialling happens. Whilst the trialling of varieties may produce positive indicators of trait performance, there remains significant uncertainty about how this will translate into farmers' experiences of the varieties, when grown under the location-specific conditions and land management choices of their fields.

Within the limited WEMA impact assessments conducted through CMMYT there is a narrow focus on the technical performance of the technology. That socio-economic constraints and farm system diversity are framed out and considered subordinate to silver-bullet solution of technology-driven yield increases, is particularly evident in the delinking of CIMMYT's own findings about risk aversion in the technology adoption of smallholder farmers from assumptions about the adoption of WEMA seeds:

> 'Risk of crop failure from drought is one of the primary reasons why smallholder farmers in Africa do not adopt improved farming practices' (AATF, 2008: 4)

> 'It is not that the basic technology to increase maize production does not exist. It is that the tools are not consistently used, largely because the farmer is

> unable to invest in them due to lack of capital, or because she is unwilling to invest what little capital she has for fear of losing her investment to drought' (AATF, 2007: 1)

In both locations of the research drawn on here, farmers expressed a preference for maize varieties that perform well under drought conditions, and CIMMYT breeding in particular has a long history of participatory varietal selection and breeding, such that developed seeds respond to farmer demand. However, in proposing, and assuming the success of, the introduction of a new technology to tackle problems of low yield and drought, the WEMA narrative finds itself contradicted by the description of a context in which it is exactly these problems that are driving farmers' unwillingness to invest in technology.

In order to analyse WEMA within a farm systems context, this paper refers to participatory rural appraisal research work carried out in two communities within WEMA's target agro-ecological zones – Kathonzweni in Makueni District (dry mid-altitude) and Kipkaren in Uasin Gishu District (moist transitional) – which aimed at understanding the contextualised livelihood strategies and constraints of maize farmers.

A number of stories of farm system change in response to histories of external interactions and social relation were described and observed in both locations. Several farmers in Kathonzweni had been the victim of purchasing what they described as 'fake seed' and in response were saving seed from local, open-pollinated, maize varieties to avoid dependence on seed supply systems that they felt were corrupt. In Kipkaren some farmers were experimenting with alternatives to maize (such as tree seedlings and sugar cane) in some cases to take advantage of what were seen as new market opportunities and in other cases in response to high input costs and continued failed harvests. Crop losses in this area were not attributed to a single common cause and in different seasons and locations occurred as a result of both low and high rainfall (e.g. drought and water-logging), as well as disease outbreaks and in-field and post-harvest pest damage.

In both locations a lack of awareness of, and scepticism about the motivation behind, the introduction of GM crops into the country, and concerns about associated health risks, further complexify the socio-cultural compatibilities of the technology. Furthermore, national regulations about the traceability of GM crops through production chains, and particularly the requirement to prevent cross-pollination with non-GM stands through the maintenance of in-field separation distances, will inevitably have implications for farms of different sizes and neighbours of differing persuasions about the technology; it may, for example, be particularly problematic in Kipkaren where the landscape is comprised of a high density of small maize plots.

Findings from these sites suggest that farming system assumptions about scale neutrality and rational adoption, evident within the WEMA narrative, sit in conflict with the complex dynamics of farm systems created by interactions between national regulations, local seed supply and grain transport and processing chains, changing market opportunities, and localised climates and geographies; and in which experiences of these system components, associated attitudes towards risk, and socially constructed scepticisms shape quite individual ‘systems of farming’.

Conservation Agriculture in Zambia

Associated with increasing concerns about soil degradation, nutrient loss, and the development of plough pans within agri-environments dominated by high-input maize agriculture (Arslan et al., 2014, Andersson and D'Souza, 2014, Giller et al., 2009), and partly in response to the withdrawal of government fertiliser subsidies under the structural adjustments of the 1990s (Baudron et al., 2007), conservation agriculture (CA) – a system of farming based on the principles of minimum soil disturbance, the maintenance of organic oil cover, and crop rotation (FAO, 2002, Kassam et al., 2009) – has received growing emphasis and acclaim within Zambian agricultural research and policy (Haggblade and Tembo, 2003, Thierfelder et al., 2012). These concerns are undoubtedly shared by small-scale farmers and governmental and non-governmental organisations alike. Established in 1996 through the national farmers union and with the support of Norwegian aid, the Conservation Farming Unit (CFU) built on the experiences of CA within and outside of Zambia and has grown substantially over two decades, and has played a significant role in the adoption of CA by, the often-claimed, 110,000 (Thiombiano and Meshack, 2009) to 270,000 (CFU estimates) farmers across the country (see Andersson and D'Souza, 2014). CFU has an established history of working in collaboration with smallholder farmers in Central Province to develop, trial, and promote CA technologies.

Based on assumptions about the universal productivity benefits and ecological sustainability of CA and extrapolations from this that see it as a means to poverty alleviation and food security, a new programme supported by the FAO, European

Union and the Government of Zambia, building on earlier similar (but shorter) successor projects aims to 'scale up' CA adoption. This scaling-up initiative consists of ambitious targets to build on and extend the outreach of CA, predominantly through lead-farmer extension programmes and linking input support through agro-dealer networks to CA practice. The four-year scaling up initiative targets over 300,000 smallholder farmers, promoting packages of minimum tillage and land preparation practices across 31 districts from nine out of Zambia's 10 provinces. In this case the targeted farming system is delineated simply on the basis of farm size (i.e. smallholder farming across the country represents a single system).

Within the articles and outputs of the CFU, the premise of its advocacy is a picture of smallholder farming, not just in Zambia but across the African continent, characterised by land degradation and declining soil productivity as a result of unsustainable practices, bound up within a cycle of poverty, institutional failings, and a historically embedded dependence on maize:

> 'Poverty is spreading, land degradation and deforestation are accelerating, and millions of farmers are busy depleting the soil upon which they and future generations depend… The combination of continuous soil inversion, the burning of crop residues and mono-cropping of maize are the principle causes of declining productivity and the degradation of arable land… When soils are judged to be exhausted, families in Zambia's Maize belts migrate locally or long distances to fell virgin or rejuvenated woodland'. (Aagard, 2010: 1, 4 & 7)

Based on this understanding of soil degradation (again often linked to assumptions about the exacerbating effects of climate change) and with a focus on small-scale and semi-commercial maize and cotton production in the moderate to low rainfall areas of agro-ecological zones I and IIa, and an initial concentration of effort within the Chibombo District, which is home to the Golden Valley Agricultural Research Trust (GART), the CFU developed a prescriptive suite of CA technologies, for common cropping systems and land preparation equipment. However, across these diverse packages and techniques, practices of minimum or zero-tillage are described within CFU outputs as the 'non-negotiable' foundation of conservation agriculture (Aagard, 2010, 2011) and Andersson and D'Souza (2014) note that, particularly central to these packages is a focus on dry-season land preparation, and planting basins that are capable of breaking established plough or hoe pans. More varied across CA prescriptions and adaptations are what the CFU describe as 'above the ground' practices, which focus on the maintenance of soil coverage by organic materials (e.g. crop residues) and, to a lesser extent, on crop rotations, inter-cropping, and agro-forestry.

Success claims associated with CA, often reinforce its framing as a silver-bullet technological response to the varied constraints and vulnerabilities of smallholder farmers:

> 'Adoption is increasing year by year and it is expected that by 2012 there will be 240,000 adopters. This is good news because ask any of the many thousands of farmers who have adopted CF and they will tell you that they are more food secure, they have surpluses' to sell, can avoid labour peaks,

> reduce costs and produce good crops in all but the driest seasons… Equally important is the fact that smallholders do not have to wait for the benefits of CF. More precise application of nutrients whether organic or inorganic, early and accurate planting, rainwater harvesting in planting zones, improved crop emergence and more optimal plant populations combine to provide a dramatic effect on crop yields in year 1.' (Aagard, 2011: 6)

> 'The agricultural production of smallholder farmers in Zambia is most affected by soil degradation, high input prices, poor produce markets and poor farming practices. In response, the newly launched [Conservation Agriculture Scaling Up] programme aims to bring conservation agriculture, a method to achieve sustainable and profitable agriculture to 315 000 farmers in nine out of Zambia's ten provinces.' (FAO, 2014: 1)

These success narratives are immediately convincing and suggest the appropriateness and relevance of CA across complex and constrained farm systems, however, the apparently rational conclusion that 'CF/CA farming systems are proven and need to be promoted as vigorously and widely as possible' (Aagard, 2011: 9), should be taken with caution. Arslan et al (2014) find that conservation tillage adoption rates across Zambia are geographically varied and highly dependent on rainfall, labour constraints and institutional presence, but their observation of high rates of disadoption of CA, and the restriction of CA practice to small sub-field, suggests that these CA successes have not been universally experienced in Zambia. Extrapolating from the results of on-farm and trial site experimentations, such as those of GART, inevitably requires assumptions about the performance of CA across varied agro-ecological conditions and is largely based on an economic framing of farming systems as systems of narrowly defined inputs and outputs.

This paper makes reference to the findings of a study conducted by the Indaba Agricultural Policy Research Institute in 2013 which followed up a nationwide household survey with focus group discussions (FGD) held in three villages in Chama, Choma, and Petauke Districts, with a total of 69 participants in total comprising 28 female and 41 male smallholder crop farmers, mainly growing maize. These discussions aimed to identify the compatibility of CA with the livelihood strategies and constraints of participant farmers.

The findings of the focus group discussions suggest too that these success narratives are not realised so straight-forwardly in reality, farm system decision making is affected by the varied institutional and economic systems of which they are a part and, moreover, farm-level production is but one component of broader household level livelihood strategies, with which CA may involve trade-offs. The majority of focus group participants in all three districts had begun to use CA practices in response to project interventions often associated with incentives, in the form of agro inputs and other materials. The rationale behind incentive schemes is that once farmers have experienced CA practices for themselves, the kinds of benefits described above will be sufficient incentive to adopt. A number of farmers have realised improved yields and reduced inputs and remain advocates of the technology:

> ‘Since my family started using ripping and planting basins, we are able to produce enough maize even in drought years much to the amazement of our neighbors ... In such drought years, people come to visit our fields to learn what we do differently and we always say, thanks to minimum tillage”. (FGD Participant, Petauke)

However, the focus groups highlighted that expiration of incentive schemes often resulted in disadoption, because of the challenges of purchasing inputs such as herbicides, which are seen as a necessity by many in the absence of complete tillage. If farmers cannot afford such purchased herbicides, they face problems of weed pressure that can depress yields unless adequate peak season labour can be found, which can also be costly.

> ‘Minimum tillage practices lead to increased weed pressure, and so you cannot get meaningful harvest if you do not apply herbicides. But since most of us do not have enough cash to purchase herbicides, practicing minimum tillage is not productive for us. It is only productive for the rich.’ (FGD Participant)

The labour requirement of CA was further highlighted as an issue in regards to the incompatibilities of early land preparation and engagement in casual labour and other off-farm income generating activities that are an important element of household livelihood strategies and the maintenance of household income in the face of uncertain productivity. Whilst farmers in all the 3 districts felt that CA tillage methods of ripping and planting basins helped them get good harvests even in years when there is low rainfall, yield gains rarely lived up to the claims of the technology promoters, and were not sufficient to be relied on in the absence of additional income sources.

For participants in Chama, rodents represent an important part of their diets (particularly as a much needed protein) and the ability to hunt rodents is integral to the broader food security of households, but this depends on a practice that is in direct conflict with CA as hunting requires the clearing of crop residues from fields, usually by burning, in the post-harvest period.

> 'Immediately after harvest period, people start hunting for mice/rodents, and they start by burning whatever residue is left in the field so that they can clearly see where the mice/rodents are hiding. Sometimes the fires start from far away in the bush and come all the way to our fields.' (FGD Participant, Chama)

In Petauke participants observed further challenges of retaining crop residues as organic soil coverage again because of trade-off with the local social systems and the broader complexities of the farm system. Particularly for those farmers for whom livestock is a part of the farm system, residues are an important source of fodder, moreover during off seasons in Petauke, fields become communal grazing lands, important not only in terms of productivity, but also in terms of the farm system playing its part within a communal system of farming, and the building of valuable social capital.

Whist CA has undoubted benefits for a production system characterised by unsustainable inputs, soil degradation, and decreasing productivity, making land management decisions within the farm system often involve trade-offs and competing resource uses that are differently compatible with broader livelihood strategies. The location-specific incompatibilities of CA experienced within certain farm systems, might call into question the merits of an objective of scaling up generic CA practices, without engaging critically with the relative costs and benefits of alternative farm system strategies.

Agricultural Input Subsidies and Extension in Uganda

In 2001 the Government of Uganda, with support from large donors including the World Bank and IFAD, passed the National Agricultural Advisory Services (NAADS) Act, which was officially launched in 2002. NAADS is part of the Ministry of Agriculture Animal Industry and Fisheries (MAAIF), and is mandated to provide public agricultural advisory/extension services. Although a central government policy, NAADS is currently being implemented through the decentralised governance structures in Uganda. Local Government (including districts, municipalities and sub-counties) administrative and technical arrangements are responsible for agricultural service delivery. Although originally established to provide extension services and advice, in practice NAADS also subsidizes agricultural inputs including improved seeds, breeds, and chemical inputs.

NAADS is one of the seven components under the Plan for Modernization of Agriculture (PMA), the planning framework of the government for the transformation of subsistence agriculture to market-oriented agriculture for commercial production. The PMA forms part of the Ugandan Government's strategy to reduce poverty as outlined in Uganda's Poverty Eradication Action Plan (PEAP). It also forms part of the macro-scale plans for economic growth and exports, and at the micro-scale is expected to contribute to rural development and poverty alleviation. Participatory approaches to planning, monitoring, and evaluating programmes are part of the guiding principles and is at least suggestive that conceptualisation of the systems in which it operates is not a purely top-down process.

The underlying assumption of PMA is that limited productivity in Uganda is caused by low levels of agricultural modernisation, for example low levels of technology and agricultural input use and low private sector investment. The farming system, then, is conceptualised within NAADS as a production unit, with a particular focus on inputs (extension services, fertiliser, etc.) and fairly simplistic assumptions about the linear relationship between whole system inputs and outputs, at local, sub-national , and even national, scales. For example, it assumes that modernisation of the agricultural sector at a local level will increase productivity and boost economic growth at the national level, and also increase incomes and reduce poverty at the local level. In fact, NAADS' stated primary objective is 'to promote food security, nutrition and household incomes through increased productivity and market oriented farming' (Government of Uganda, 2001: Section 5(a)).

NAADS also assume that a nested set of community-level farmer groups, which are represented within farmers' forums at the sub-county, national, and district level, will both ensure the efficient outreach of extension and inputs and provide a mechanism for more bottom-up participatory inclusion of individuals and households in the NAADS process (NAADS, 2001).

A number of success stories of transitions to commercial production and agri-business are detailed in the promotional material of NAADS, suggesting that, at least in some cases, the benefits of the scheme have been realised. The evaluation of experiences of NAADS at the farm systems level presented in this paper draws upon primary data collected during fieldwork in Uganda throughout 2012. Data was collected from 4 villages in Jinja District, eastern Uganda. Semi-structured interviews and FDGs, including participatory appraisal methods, were used to analyse farming changes in the region from 1960-2012. This included sub-national (district-level) stakeholder workshops, where representatives of the technical and administrative units responsible for service delivery participated.

From this analysis we identify three major discrepancies between how farming systems are conceptualised and framed within the NAADS approach and how they are experienced 'from below'. Conceptualisations 'from above' overlook: 1) the institutional factors that influence differential access to extension services, including agricultural inputs, between individual farm systems; 2) intra-household dynamics that shape control and use of resources at the farm scale; and 3) the resource constraints that prevent farmers from sustainably modernising agricultural production.

Although agricultural input subsidizes are widely implemented across the country, farmers within the same farming system have differential access to extension services and subsidised inputs. Input subsidises are often distributed to registered groups, for example farmer's groups, which represent a collection of individuals within the same geographical area. Farmers described how a village may only have one registered group receiving input subsidies and within that registered group only few will receive inputs initially, and the process is susceptible to elite capture.

> "as they come, they find us in groups, they identify active groups….because if you don't have money, you can't continue…. You see, if I am trained that I should keep [crops] in a good store, the quality should be like this, you need to use herbicides and pesticides, you need to learn the pest control in the storage and about the marketing, you need to bulk food, but when you don't have money then you don't do it, I don't do it"
>
> (Male Interviewee, Bituli Village, 2012).

> "the government have a policy of bringing NAADS, but those people when they come on ground they only choose a few people and others are left out. Like the time they brought groundnut seeds, only one person got it...we are also expecting women to also get beans, but it has not reached, it is affecting us"
>
> (Male Interviewee, Bukolokoti Village, 2012).

Intra-household dynamics shape how inputs are accessed and used within the farm system. In theory any adult in the household can access extension services and subsidized inputs; however, the utility and effect of inputs varies across farm systems depending on household level dynamics. During FGDs several female farmers suggested that women obtained subsidised inputs, but then inputs were used, and in some cases sold, by the male head of household or a co-wife, thus limiting the positive impact of input subsidies on productivity.

> "For me I am a co-wife. Then the little money you have dug…or the resources you have, they take it to other women"
>
> (Female FGD Participant, Bukolokoti Village, 2012)

Intra-household dynamics and access and control over resources are shaped by wider socio-cultural factors. The complex nature of household structures, which includes polygamous households, is also overlooked by NAADS, with implications for the assumptions that are made about the input-output nature of the production systems. Implementation through existing institutional structures can lead to unequal access to inputs and reinforce existing power dynamics, thus creating winners and losers within a farming system. Inadequate attention given to implementation processes, the influence of existing power structures, and intra- and inter-household dynamics has limited the ability of input subsidies to consistently increase productivity.

Thirdly, a narrow focus within NAADS on the modernisation of farm production, is incompatible with the persistent resource constraints experienced by farmers:

> "according to researchers and NAADS you need improved seeds, you need to buy new ones, and that is when they do well. But for us, because at times you find you have sold off everything and the money is not enough, you find yourself replanting those seeds…not using the inputs and then they don't do so well"
>
> (Male Interviewee, Bituli Village, 2012)

In some cases farmers are selling off or renting out assets and seeking off-farm employment opportunities. The impact of modern seed varieties and chemical inputs has also led to the loss of some traditional stress-resistant varieties. The narrow focus on modernisation of agricultural production and promotion of improved seeds and chemical inputs in current policies has locked some farmers into inflexible 'modern' systems of farming.

Table 1: Summary of the three case studies presented in this paper

Case Study	Location	‘From Above’		‘From Below’	
		Actors	**Conceptualised Farming System**	**Actors**	**Experienced Farm Systems**
Genetically Modified ‘Water Efficient Maize for Africa’	Kenya	Public-private partnership between CIMMYT and Monsanto, brokered by the AATF	Smallholder rain-fed maize farming Across agro-ecological zones Vulnerability to drought	Smallholder farmers in Kipkaren (Uasin Gichu District) and Kathonzweni (Makueni District)	Societal interactions and interdependencies (across agricultural input supply chains) Attitudes towards technology and risk Interactions with, and trust in, regulatory institutions Multiple land and resource pressures
Conservation Agriculture	Zambia	Zambian National Farmers Union’s Conservation Farming Unit	Land degradation and soil erosion High/unsustainable input costs Low productivity Soil erosion	Smallholder farmers in Chama, Choma, and Petauke Districts	Competing uses for crop residues Weed management challenges and herbicide costs Competing labour demands Multiple land uses (due to insecure property rights) including communal grazing and rodent hunting
National Agricultural Advisory Services	Uganda	Ministry of Agriculture Animal Industry and Fisheries Jinja District Local Government (district and sub-county)	Production units delineated on the basis of broad agro-ecological zones Simple relationship between inputs and outputs Farmers need enlightening about modern methods and technologies that will translate into productivity gains and poverty alleviation	Smallholder farmers in Jinja District	Farmers responding to multiple pressures and opportunities Gendered division of labour and intra-household dynamics Corruption, power dynamics and institutional arrangements that limit access to extension services and inputs Negative social, environmental, and economic associated with input subsidies

Discussion

The three case studies present a consistent and familiar narrative of real-life complexities that are not fully captured within the grand designs of broader system interventions. The case of WEMA in Kenya is one in which the interactions of technology regulation, land constraints, and social relationships are overlooked within a public-private technology development initiative that targets impact-at scale. The Conservation Farming in Zambia case study reveals the ways in which generic farming system prescriptions can be incompatible with the resource constraints and competing land use priorities of smallholder farm systems. In the final case study, agricultural inputs in Uganda are shown to be subject to a variety of intra-household and institutional dynamics and may effectively lock farm systems into unsustainable systems of farming. They demonstrate potentially problematic incompatibilities between agricultural developments designed to suit broadly defined and aggregated farming systems (defined on the basis of agro-ecologies, cropping systems, or farm sizes) and the complex realities of the farm system experienced by farmers.

In accordance with the concept of Giller (2013) of inter-farm diversity and interdependency, each case reveals a variety of nuances of farm system operations, from intra household and institutional dynamics that shape resource access and use (Uganda), to multiple livelihood strategies and trade-offs (Zambia), and varied systems of farming, reflected, for example, in communal land grazing (Zambia) or individual attitudes towards risk (Kenya). What is evident from the complexities and diversity of farm systems is that all manner of 'farming systems' could potentially be constructed – delineated on the basis of crop types, land size, household structures, levels of market engagement, geographic location, to name but a few generic ones – with each conceptualisation inevitably involving sets of assumptions about farm properties and commonalities.

Clearly the larger the focus of an intervention or research project and the greater number of farms and households captured within it, the more simplistic these common denominator assumptions must become. Arguably, new emphasis on achieving 'impact-at-scale' within public private agricultural research and development partnerships; the increasing attention being paid to the role of global climatic systems over long time horizons; and the ever-growing prioritisation of broadly defined food security agendas within international targets and national policies; are contributing to a growing focus on broadly aggregated systems.

Dixon et al.'s (2001) concept of farming systems as 'populations of individual farming systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate' (p. 13), is a useful concept for thinking about the appropriate scale and targets of such intervention. However, on the basis of a constructivist understanding of the farming system, which recognises that its boundaries and characteristic dynamics represent the assumptions and simplifications of those conceiving the system, the identification of Dixon et al.'s system as a pre-condition for designing and targeting interventions is subject to political bias. Systems might just as easily be constructed around interventions, with the potential that projects and interventions focus in on common denominators across farm systems as the basis for their delineation, rather than acknowledging their diversity. Particularly in the Kenyan and Zambian cases, we observe a justification of intervention on the basis of a reductionist interpretation of the target farming system.

The case studies further indicate the value of a conceptualisation of farming as a set of decisions shaped within multiple nested systems. This is evident in the farming systems concept of Shaner et al. (1982), which suggests that the household manages the farm 'in response to physical biological and social environments and in accordance with the household's goals, preferences and resources' and that 'the farming system is part of larger systems' (p.37). In the case of conservation agriculture for example, without interrogating the connections between household resource constraints, social interaction and cultural norms at the village scale, agro-climatic changes, and the geographic distribution of extension services, we are left with an incomplete explanation as to the observed phenomenon of disadoption.

Developing separate understandings of distinct and bounded systems offers only limited scope for understanding the links between on-farm decision making and broader political, social, economic, and environmental processes. Here Sumberg et al.'s (2013) concept of 'systems of farming' represents a useful foundation for rethinking the nature and dynamics of a multi-level system. Systems of framing research, requires constructing boundaries not around geographic spaces, but around the socio-political processes, resource constraints, and flows of information and knowledge that shape the livelihood strategies and practices of farmers. As Shaner et al. indicate, these are processes that take place in the overlapping spaces between multiple systems at multiple scales. The case studies presented demonstrate intrinsic connections between the constraints, institutions, relationships and histories of the farm system and the decision-making, attitudes, and risk-perceptions of the farmer. In these cases, complex and local-level interactions give rise to multiple rationalities within decision-making.

It is in interrogating these cross level dynamics that an understanding of the relationship between large scale interventions and farm level experiences can be built. Such an understanding will be important not only for designing appropriate interventions, but for creating enabling environments for commonly negotiated pathways of development at all scales. Giller's warning against seeing the farming system as a 'single recommendation domain' is pertinent. It is unlikely that impact-at-scale agricultural developments or adaptations to climate change are going to involve a single change to the farming system (such as the introduction of a technology), but will rather be associated with transformations in relevant policy sectors, infrastructures and markets, social relationships, and even cultural norms. The Kenyan case study, for example shows regulatory barriers that make the WEMA agricultural development pathway unviable at a number of points within the system, and in the Ugandan case, it was evident that input and extension support will fail to support certain farmers out of marginal production systems without changes to structures of access and availability at village and national scales.

In the context of grand challenges for agricultural development and investments in impact-at-scale development strategies, FSR has an important and challenging role to play in understanding how these interventions become experienced at the farm scale. Across the case studies described in this paper, we have built up a picture of farming as a constructed system of decision making embedded within, and shaped, by multiple social, environmental, economic, political, and cultural systems at multiple scales. Where the complexities of these systems are overlooked, or where there are conflicting pressures from these different systems (e.g. where national policy contradicts development programme objectives), then these impact-at-scale interventions are likely to be experienced rather differently than they were envisaged. Understanding the system as a construct and a decision-making domain has particular implications for how FSR research is conducted, suggesting that there is a need for including alternative and experiential knowledges (of farmers, extension workers, crop breeders, climate scientists, policy-makers and more) in a negotiation of system boundaries and dynamics. In some respects a return to the participatory foundations of the FSR movement. Bringing together multiple knowledges within a participatory and deliberative FSR, holds potential both to better understanding the complex processes that transcend multi-level systems, but also to provide a forum for transforming these dynamics and co-designing pathways that have impact-at-scale as well as local appropriateness.

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