DOI: 10.5836/ijam/2017-06-01

In search of farmer wellbeing

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ABSTRACT
The mental health and wellbeing of farmers has become an issue of concern for the UK agriculture community. The author used the opportunity of a Nuffield Farming Scholarship to explore how other farming nations are experiencing this challenge. The author suggests there is much we can learn, particularly from the approach taken by Australia and New Zealand.

KEYWORDS: mental health; stress; suicide; resilience; United Kingdom

Whilst it was once seldom talked about, the agriculture community is now increasingly speaking out on the issue of mental health. It is widely acknowledged that agriculture and horticulture can be a highly stressful occupation and the industry is exposed to a unique set of circumstances and stressors. Long hours (often spent working alone), rural remoteness, the unpredictability of weather, downward price pressure, market volatility, masses of 'red tape' not to mention the 'glass bowl effect' of living one's life in a small, rural community – these are just some of the stressors facing many farmers and growers.

It has undoubtedly been a turbulent few years for United Kingdom (UK) agriculture. Farming welfare charities report increasing numbers of calls to their helplines suggesting levels of stress, depression and burnout amongst farmers are on the rise. Stress is often thought to be a key factor in many of the accidents, injuries and illnesses taking place on farms as people become prone to risky decisions or driven to carelessness when stressed, tired and lacking sharpness. It is also important to recognise that untreated, unaddressed depression can increase the possible risk of suicide. Unfortunately, England's national suicide prevention strategy identifies farmers as one of the occupational groups with the highest risk of suicide (Department of Health, 2012). Meanwhile, suicide itself is now the single biggest cause of death for men aged 20-49 years in England and Wales (Office for National Statistics 2015).

Sadly, mental health is one of the biggest health challenges facing society today. One in four people in the UK are likely to experience a mental health difficulty in any given year (Mental Health Foundation 2015). Although attitudes are gradually changing, it remains a taboo topic for many. This is particularly thought to be the case for a lot of farming men where a level of social conditioning over generations is thought to have reinforced a view of masculinity whereby men are expected to be tough, self-reliant and successful. This can exacerbate the stigma around mental health as it means admitting to struggle and having to ask for support is taken as evidence of personal weakness or failure. This often hinders people's willingness to speak about the issue and to seek help for themselves. A recent study by the Irish Association for Counselling and Psychotherapy found the farming community the group least likely to talk to a friend about stress or depression with just 31% saying they had done so compared to the national average of 49%. Just 7% of respondents from the farming community said they would speak to a doctor and only 5% said they would speak to a counsellor or psychotherapist about personal problems compared to a national average of 21% and 13% respectively (Irish Farmers Journal 2015).

I am certainly not attempting to paint a picture where all farmers and growers are stressed out, depressed or suicidal. However, high levels of stress and poor mental health are becoming an issue of concern. Having spent my career working in the agriculture industry whilst also being a practicing counsellor and therapist, this is an issue which is of great interest to me. On that note I was fortunate to be awarded a Nuffield Farming Scholarship made possible through the support of the John Oldacre Foundation. This allowed me to explore how other countries are experiencing this challenge in their farming communities.

In addition to Europe, my studies took me to Australia and New Zealand. Both countries are facing significant challenges with rural mental health and farmer suicide. However, I found a lot of encouraging activity underway seeking to address this. What are some of the things they are doing and what might we learn from their approach?

Whilst mental health in UK farming is clearly acknowledged as a problem and whilst many people working in the industry can confidently supply anecdotal examples that highlight this, we are perhaps lacking in measurement or hard data that would help give a much more detailed idea of the extent of the problem. It could be argued therefore that the true scale of the problem remains unknown and similarly the effectiveness of initiatives to address the problem are perhaps not as understood as they could.

By comparison both Australia and New Zealand have invested in developing robust data. This has included commissioning academic research, as well as capturing practical data through farmer surveys. Dedicated health

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and lifestyle drop-in clinics have been a feature at agricultural shows and farm events in both countries for several years now. These initiatives have gathered anonymous data from thousands of farmer interviews and assessments to build up a measurable picture of levels of stress, depression and burnout. Faced with such detailed evidence of the extent of the problem, their governments, farming industry and wider society has had little choice but to acknowledge and address a problem that is often hidden and to make more funding and resources available for the industry to utilise.

Australia is fortunate to have specialist institutions such as the Centre for Rural & Remote Mental Health and the National Centre for Farmer Health. Both focus on translating research into practical intervention strategies to improve rural mental health and wellbeing. Whilst we do not have such equivalents in the UK it's important to find routes by which we can further develop our evidence base in this area. This might include collating existing data into more practical, meaningful form or using mechanisms within farmer organisations, government agencies and the media to regularly survey and collect data on issues of stress and mental health among farmers.

I witnessed a concerted effort to increase farmer knowledge of mental and emotional health through use of specialised literature, online initiatives, educational workshops, themed events, training as well as widespread use of the agricultural press to get messages out to the industry. This is helping to encourage open discussion, dispel myths and normalise the issue so that associated shame, stigma and taboo is gradually eroded thereby making it easier for people to ask for help.

Work is underway to train the whole supply chain in mental health awareness and suicide prevention skills. This has been done by developing educational workshops and structured training programmes specifically for the farming industry. With the help of extension advisory services, these have been rolled out nationally across New Zealand to farmers and rural community groups. Most importantly they have targeted those associated rural professionals who are venturing down farm drives every day such as vets, agrochemical reps, bank managers and accountants etc. The aim is to develop a vast rural detection network skilled in spotting warning signs of possible distress in people, confident to engage in supportive conversation with those who may be struggling and knowledgeable of services to which that those in difficulty could be referred.

Whilst there are small pockets of activity where this sort of training is happening in the UK, the upskilling of farming communities and the wider rural workforce in this fashion really needs to be accelerated. It was also interesting to learn that the topic of mental health and wellbeing has been successfully integrated into the curriculums of leading agricultural colleges in New Zealand. Should we be aiming for the same across land-based, educational institutions in the UK? Investment in this area is necessary if we want future farmers to be well equipped to understand the many stresses of running a farm business and for them to learn healthy strategies for looking after their mental and emotional wellbeing.

Perhaps the most impressive aspect of both countries engagement on the topic of farmer mental health is the way essential, emergency-type response work 'downstream', is being balanced with more pro-active, preventative initiatives 'upstream'. Downstream it's about having a strong foundation of services and facilities in place to help those presenting as stressed, exhausted, overwhelmed or close to breaking point. Meanwhile upstream initiatives are focussed on improving awareness of individual wellbeing and supporting farmers to develop healthy skills and strategies so they are better placed to cope with the ups and downs of farming life.

This upstream activity aims to reduce the number of farmers needing to approach more 'emergency'-type clinical or medical services. It also aims to ensure that they are sufficiently informed and aware so if they do begin to struggle that they seek out help in good time.

Delivering health provision and access to services in more remote, rural areas of the UK remains an ongoing policy challenge. However, the UK is nevertheless fortunate to have some excellent farming welfare charities working in this 'downstream space'. Whilst they offer various forms of support, their work by its nature tends to be reactive with their limited resources rightly prioritised to focus on those in most immediate need. Therefore, appropriate routes to deliver upstream, preventative activity need to be found. Impressively, in New Zealand, this has been achieved by respected, leading organisations within the agriculture and rural sector stepping into this upstream this space. For instance, this includes the farm extension service, DairyNZ as well as a dedicated farmer wellbeing initiative named 'Farmstrong', which has been funded by commercial agricultural organisations. Is there a role therefore for some of the UK's leading farmer-facing organisations to become more actively involved imparting practical, proactive measures on wellbeing to farmers?

In this upstream space the conversation is moving to one of, 'How can we help farmers improve their overall wellbeing and ensure they are better placed to deal with the stresses and pressures of farming?' 'Resilience' has become something of a buzz word in agriculture in recent years. Whilst it's common to hear talk of crop resilience, soil resilience, resilient farm systems etc., in the same way, it's important to consider how we can build up our mental and emotional resilience. Resilience can broadly be defined as one's willingness and capacity to manage and cope with stresses. It is about understanding and accepting there will be both good and difficult times and consequently having supportive strategies to manage one's thoughts, behaviour and reactions. Resilience doesn't mean complete elimination of stress as a certain amount of stress is necessary to help us achieve goals in our life. Yet having emotional resilience means we can adapt and move forward in a positive direction amid adversity.

During my Nuffield travels I encountered farm extension services delivering workshops on 'Positive Thinking', kiwifruit growers learning practical breathing techniques to help them better manage stress, farmer groups being coached by 'sleep doctors' to help them achieve a restful sleep and even farmers learning 'Tractor Yoga'. By using credible, evidence-informed techniques to help farmers invest in building their inner resilience the idea is to help farming populations stay healthy and productive in these difficult, pressurised times.

In summary, it seemed to me that Australia and New Zealand are really beginning to recognise that we cannot have a profitable and productive agriculture and horticulture industry without healthy and resilient people at its centre. I believe this a message we all need to take to heart during these difficult and uncertain times for the farming industry in the UK and beyond.

About the author

Aarun Naik is a counsellor and psychotherapist with a background in the agriculture and horticulture industry. He is based in the North West of England and has a particular interest in farmer wellbeing. He also delivers mental health awareness training to farmer groups and organisations working in the agriculture sector. He is a UK Nuffield Farming Scholar. His Nuffield report, ''Supporting farmer wellbeing: addressing mental health in agriculture and horticulture'' can be viewed at www.nuffieldinternational.org/rep_pdf/1476692236Aarun-Naik-report-2015.pdf

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REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-04

The Potential of Farm Partnerships to Facilitate Farm Succession and Inheritance

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ABSTRACT

The rising average age of farmers and low level of young farmer entry is viewed as problematic on a global scale and farm partnerships are presented as a possible means by which farm succession and inheritance could take place in a timely manner. Using the example of Ireland, this research investigates a recent proposal by government to introduce a tax relief as an incentive for farmers to part take in farm partnerships. In this discussion, a hypothetical microsimulation model is used to investigate the possible outcomes of such a tax relief, with scenarios created to examine how this would materialise. It draws on the Teagasc National Farm Survey data which provides Irish data to the Farm Accountancy Data Network in the European Commission. The findings illustrate that even with a tax relief, cattle rearing farms would struggle to reap any economic benefit from entering a farm partnership, while their dairy counterparts would receive more value from tax reliefs. Results also indicate that farm viability will play a large role in whether or not collaborative farming is viewed as an option for farmers.

KEYWORDS: Farm partnership; succession; inheritance; collaborative farming

1. Introduction

Contemporary agriculture faces a myriad of challenges ranging from farm viability to reducing environmental impacts and addressing animal health and food security issues. One of the most important issues farmers face is that of business continuity, of which succession and inheritance planning is an integral part. Succession denotes the transfer of managerial control, while inheritance describes the transfer of assets[7]. Farmer decision-making around succession and inheritance is complex and multifaceted, and influencing factors are economic, personal and social, with every farm succession and inheritance route an idiosyncratic one (Conway et al., 2016). Due to the complexity of the situation, policy makers are challenged in their endeavour to encourage transfer of farm ownership or management to a younger generation. The increasing average age of farmers (Figure 1) globally has been problematized as a situation of lower production, efficiency and technology adoption correlated with older land-holders (Lobley et al., 2010; Howley et al., 2012; Zagata and Sutherland, 2015). This perceived problem of reduced productivity and efficiency as a function of an ageing farm population is under particular scrutiny within Europe, North America and Australasia where the competitiveness of the agricultural sector is high on national economic development agendas.

With a view to addressing the ageing profile of farming in EU contexts, a range of strategies and policy interventions have been put in place over the last three decades or so, from early retirement schemes to various nationally-based tax incentives in an effort to encourage a more structured and predictable rate of entry into and exit from farming as an occupation. Farming is also construed as a 'way of life' as much as an occupation, and it is contended that emotional and other cultural and symbolic associations with agriculture have confounded attempts to introduce policy in a format that can take account of these complexities (Conway et al., 2016; Inwood and Sharp, 2012; Gasson and Errington, 1993). The issue remains, however, that policy at both EU and national levels has not apparently been sufficiently innovative to alter the established dynamic of low rates of transfer and an ageing farming population. The issue is

Original submitted August 2016; revision received February 2017; accepted March 2017.

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[7] For this research both succession and inheritance are used in conjunction as both processes are being discussed.

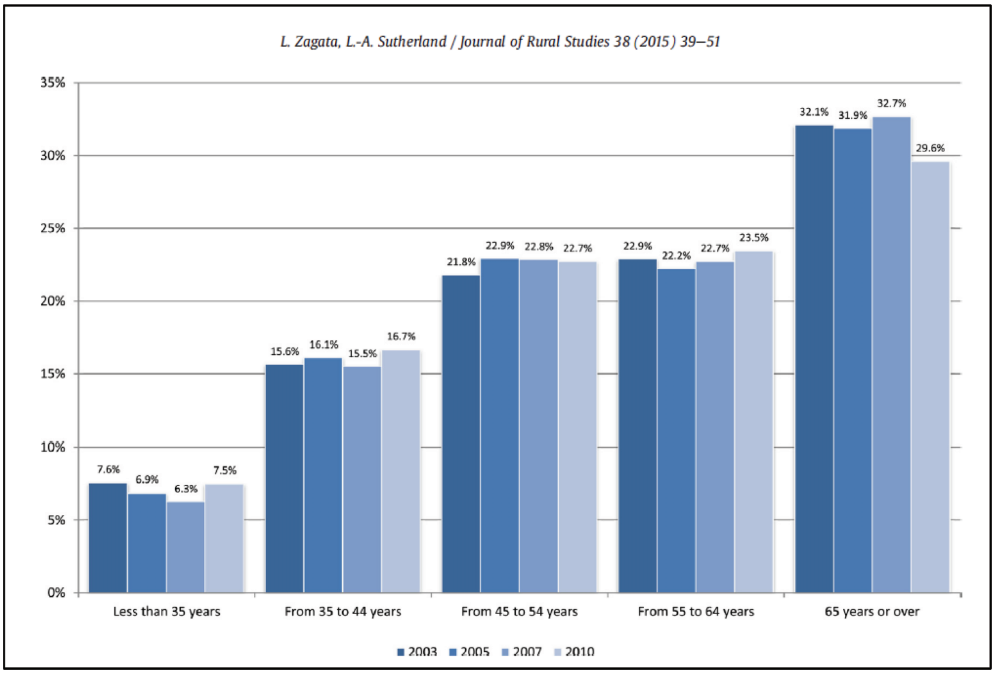

Figure 1: Share of farm holders by age category for the years 2003 – 2010 (Zagata and Sutherland, 2015)

particularly evident in the Irish context, where the vast majority of farm transfers are made via inheritance, and generally take place within families. This has culminated in a particularly stifled land market and very limited pathways to entry for young farmers (Hennessy and Rehman, 2007; Matthews, 2014). From an economic competitiveness perspective, the notion of engaging younger farmers in agriculture as a policy priority also implies their intention to actively farm in a productive way.

One strategy for change currently being developed in the Irish policy context is the introduction and promotion of farm partnerships across all farming systems. The rationale behind farm partnerships is that they incentivise a new set of working arrangements between older and younger farmers, as a way of providing more options for younger farmers to enter farming in an active and productive way, with recognised status and responsibilities and agreed sharing of the farm profits (Macken Walsh and Roche, 2012). Farm partnerships are also held to create more opportunities to maximise efficiencies and profitability through combining expertise, experience and resources and through convincing older farmers of the benefits of earlier farm transfer. The benefits associated with young farmers being involved in an enterprise from the point of view of encouraging farm transfer have been widely cited. Potter and Lobley (1996) have coined the terms 'succession, successor and retirement effects' to describe the processes whereby an identified successor or lack thereof can significantly influence the original holder's level of interest and investment in the farm when approaching what should be their own retirement from farming. Potter and Lobley (ibid) argue that 'farmers without successors…seem significantly more likely to be disengaging from agriculture' (p. 329). The successor effect thereby refers to the positive impact which a successor can have on a farm once he or she becomes actively involved in the running of a farm and decision-making processes The retirement effect generally has a negative impact on farms, i.e. the process of semi-retirement tends to be characterised by de-intensification and liquidation of assets if there is no successor present. The contention is that a farm partnership could promote the successor and succession effect together with creating an environment for shared decision making and control, while stifling the negative outcomes of the retirement effect (ibid).

A key aim of this research is therefore to provide a critique of the current mechanisms relating to farm succession and inheritance, through assessing the plausibility of farm partnerships as a means by which farm succession and inheritance can be facilitated. The issue of financial viability of a farm partnership is a second crucial aspect; if the partnership cannot sustain the farm and provide a reasonable income for those involved, it is unlikely to be embarked upon regardless of its capacity to encourage farm succession to take place. The paper is structured to initially provide a comparative analysis of farm partnerships internationally (including Ireland) as a mechanism to support succession and inheritance, focusing on structural and policy aspects. Secondly, taking the example of Ireland, it examines the financial implications for farmers of embarking on farm partnerships with a view to farm succession. It does this by applying a hypothetical microsimulation model to assess the value of a range of tax reliefs offered as incentives to enter partnership arrangements, and to proceed on to farm transfer. For this research the terms succession and inheritance are used in conjunction due to the complexity of the farm transfer process, but also given the fact that both succession and inheritance take place in the microsimulation results.

2. Collaborative Farming Models To Support Succession And Inheritance

Farm partnerships come under the umbrella term 'collaborative farming'. Other arrangements considered collaborative farming include contract rearing, share farming, cow leasing and long term land leasing (Curran, 2015).

Forms of collaborative farming, particularly farm partnerships, have been identified as a step towards farm succession and inheritance. Commins and Kelleher (1973) (and later Gasson and Errington, 1993) refer to the succession process as a 'ladder' of responsibility which is gradually ascended by a young farmer entering a business. Generally the process of retirement and succession is a gradual one that follows clear phases, hence the ladder analogy. The first phase is where the farmer shares the workload with the successor. Following this, management is slowly passed over to the successor before eventually the successor becomes the sole operator. The identified middle phase is likened by Gasson and Errington (1993) to a farm partnership. A farm partnership involves the pooling of resources and skills of the parties involved, a contract is agreed which specifies profit shares for the parties involved and sets out levels of input each partner will have. Macken Walsh and Roche (2012) describe a farm partnership as a situation in which 'two or more farmers join resources and efforts in order to acquire various benefits' (p.2).

3. Opportunities Of The Farm Partnership Model

Partnerships facilitating succession and inheritance

The transfer of decision making responsibilities can be a contentious issue for farm successors with older farmers retaining control over decisions until they exit farming. A farm partnership provides an avenue for responsibilities to be more formally shared between farmer and successor, thus reducing the possibility of a successor becoming frustrated over time (Errington, 1998).This transfer of responsibility can benefit the farm by allowing young farmers bring new ideas to the business. Chiswell (2016) found that farmers in the UK were aware of the importance of these new ideas with some interviewees articulating their importance due to the ever changing nature of the sector. Also in the UK context, Ingram and Kirwan (2011) evaluated the Fresh Start Initiative, a scheme which matched new entrant farmers with retiring farmers as a means of giving younger farmers a start and older farmers a gradual exit strategy. However, this was not seen as hugely successful because there were insufficient profits from some partnerships to sustain two salaries. In contrast, Gasson and Errington (1993) describe the partnership model as an excellent means by which a successor can gain managerial responsibility prior to fully taking over a family farm. In addition they assert that farms where a farmer-son partnership is in place tend to expand far more than their counterparts. Ingram and Kirwan (2011) also note that farmers are more willing to cooperate with family members. Many Dutch farms are in partnerships which facilitate the process of gradual succession (NRN, 2012). In New Zealand farming in partnership is popular amongst dairy farmers, with McLeod (2012) referring to forms of farm partnership as 'succession options'. In the Dutch case a 'maatschap' allows a successor to build up a share in the farm business over time and also facilitates the gradual transfer of control from the farmer to their successor (Gasson and Errington, 1993). This form of partnership is utilised by the majority of farms in the Netherlands with aspects such as the sense of security created for a successor in knowing that they will eventually take over the farm being lauded (Johnson et al., 2009; Van der Veen at al., 2002). In the case of New Zealand, the dairy industry has a well-developed career structure which gives young farmers the opportunity to begin farming and has exit schemes available for older farmers such as phased exit strategies (CIAS, 1996). Up to 40% of New Zealand's dairy farms operate under share milking agreements, indicating a high success rate, while over 20% of all dairy farms in Norway are managed using some form of partnership (McLeod, 2012). However, McLeod (2012) notes that sheep and beef farms tend to use 'more traditional' forms of succession and inheritance. Until recently, registered partnerships in Ireland were only an option where at least one partner was operating a dairy system; however, partnerships were introduced for all farming systems as of spring 2015.

Risk reduction

A critical issue in partnership arrangements is how decision-making and risk assessment are shared. Groom et al. (2008) note that farmers are generally risk adverse, which is exemplified by Hardaker et al. (2004) who suggest that farmers tend to avoid the uptake of new technology if they have little experience with it. Similarly, Vollenweider et al. (2011) found that uptake of the Rural Environment Protection Scheme (REPS) was dependant on the ability of the associated subsidies to smooth income over time and thus reduce financial risk. Partnership arrangements however, may promote risk reduction in net income by risk sharing and diversification effects; thus partnership arrangements should be an attractive option for farmers. Moreover, the risks associated with introducing new technologies can be shared among farmers (Larsen, 2008). McLeod (2012) cites the perceived risk involved in joining a farm partnership as a contributing factor to a final decision, going on to reference sharing of risks as a potential benefit to being in a farm partnership. For retiring farmers, a partnership may be perceived as attractive as it allows them to retain some control over the farm, particularly if they do not have a source of retirement income. Entering a farm partnership does not require the farmer to transfer any land to a successor, possibly reducing the perception that they are losing control of their farm which often deters farmers to engage in succession/inheritance (Lobley et al., 2010). From the perspective of a successor, the formation of a partnership can confirm their status on the farm. In many cases successors may be unaware if they will definitely inherit the farm or not, and often do not receive payment for the work they undertake (Gasson and Errington, 1993). The partnership contract in the Irish case incorporates the sharing of profits, which in turn reduces the risk of a successor abandoning the family farm as a result of becoming frustrated with a lack of pay or responsibility and seeking opportunities outside of farming.

While risk reduction has been outlined as a benefit associated with farm partnerships, entering a partnership can be surrounded by uncertainties given that it is a relatively novel form of arrangement, particularly within the Irish context. With farmers described as risk averse it is expected that they may be negatively predisposed to a new management structure. In relation to smaller farmers in particular, Crowley (2006) finds that they are 'very slow to take risks and to become fully integrated in commercial markets unless forced to do so' (p. 55). She suggests that they may be affected by both cultural and economic factors when making decisions around change and may be more likely to rationally keep to a prior path rather than embarking on an uncertain venture (such as joining a farm partnership), thus avoiding potential risks associated with unfamiliarity. Partnerships have developed in a variety of ways in different countries, with diverse levels of uptake. At present they are popular amongst farmers in New Zealand, France, Norway and the Netherlands (Johnson et al., 2009; McLeod, 2012).

4. Methodology And Data

In 2002, registered Milk Production Partnerships (MPP) were made available to dairy farmers in Ireland based on the Groupements Agricoles d'Exploitation en Commun (GAEC) system. Partnerships in Ireland are most similar in structure to those in France, known as GAECs (Groupements Agricoles d'Exploitation en Commun). The GAECs facilitate the bringing together of small scale farms with the objective of making farming more viable. Policy changes in French agriculture have accommodated the GAECs in order to encourage farmers to enter or remain in an arrangement. In general, governments favour agricultural land mobility via inheritance tax incentives, or lack of land transfer taxes (Bird and Slack, 2002). In Ireland, for instance, there are numerous taxation incentives surrounding agricultural land transfer (Leonard et al., 2017), while in the Australian case there is no inheritance tax (Ernst and Young, 2013). Initially partnership agreements were confined to bringing together two producers who each had a holding and a milk quota; however, in 2003, new regulations were introduced which aimed to expand the use of partnership arrangements. One of the features of this change was to provide for partnership arrangements between a parent and son/daughter and in conjunction with this, under the restructuring scheme, to allow priority access to quota to the son/ daughter as a new entrant to dairying. Although initial interest in partnerships was low there has been significant uptake in recent years, particularly in the new entrant/parent arrangements. In 2016, partnerships were made available for all farm systems to enter and current figures indicate that there are 1,556 registered partnerships in Ireland (DAFM, 2016). Figure 2 presents a breakdown of these partnerships by system, it is clear that dairy (including dairy and other) is the dominant system involved in farm partnerships in Ireland, with beef (including beef and other) being the second most likely system to engage in such a farm arrangement.

Section 5 focuses on an analysis of the different tax relief schemes available to farmers in partnerships in terms of how they potentially impact on succession and inheritance decision-making. It does this through the use of microsimulation modelling to produce a comparative analysis of 2 (hypothetical) base farms involved in farm partnerships, with one farm in the pre-2016 and the other in the post-2016 (proposed) Succession Farm Partnership Scheme (SFPS), in terms of how each fares out in terms of financial viability. In addition to this, farms in pre-2016 scenarios will not receive assistance from the 'Support for Collaborative Farming Grant Scheme' (SCFG - discussed below). Here, details of the different tax reliefs under each scheme is first outlined, followed by a description of the hypothetical simulation model applied, and then the presentation of a series of scenarios for succession and inheritance linked to partnership arrangements.

Financial incentives/tax reliefs

In December 2015, the Irish government announced an income tax credit (subject to EU approval) to encourage the transfer of farms within families (i.e. the SFPS). A new register will be created for farm partnerships in which one partner is a young trained farmer. This register will allow an annual €5,000 income tax credit to be split between the partners in a farm partnership for a five year period. One of the conditions is that 80% of farm assets must be transferred within 3 to 10 years of applying to register a partnership to avail of the tax credit.

Changes introduced as part of the introduction of the most recent CAP reform have embraced the concept of multiple payment thresholds to registered farm partnerships across all CAP Pillar I and Pillar II schemes. The concept that farmers entering into a registered farm partnership should not be in any way disadvantaged when compared to farmers operating in their own right has been embraced by policy holders. Technical issues can still arise that cause problems for farmers obtaining their multiple payments.

An SCFG has also been introduced to cover 50% of the costs incurred in entering a farm partnership. This grant aims to cover some of the legal, financial and advisory fees associated with setting up a collaborative farming arrangement and the maximum payment is €2,500. Those in a Department of Agriculture, Food and the Marine (DAFM) registered farm partnership can also avail of stock relief in two ways, with young farmers receiving 100% stock relief for the first four years after setting up as a farmer. Other partners can avail of an enhanced stock relief at a rate of 50% on their share of the increase in stock value. Farmers can also benefit from a higher investment ceiling for the Targeted Agricultural Modernisation Scheme (TAMS) and multiple payments under GLAS, ANC and the Organic scheme.

Hypothetical microsimulation modelling

The area of farm succession and inheritance lends itself to a high level of complexity given the factors involved, such as, the wide-ranging impact of such a decision on the lives of the farmer, successor, and their families (Inwood and Sharp, 2012). For this research, the chosen scenario used to analyse the economic impact of different routes to succession and inheritance is that of entering a farm partnership. Hypothetical microsimulation is the most appropriate methodological approach as it allows for complexity to be removed to an extent and an assessment of different changes to be made at a micro level (O'Donoghue, 2014). This method facilitates the projection of income streams for both parties, whilst allowing for farm level changes (such as income increase/decrease and farm size adjustment) to be made for each scenario.

Microsimulation models use data on micro-units (e.g. households, firms, farms, etc.) to simulate the effect of policy or other socio-economic changes on the population of micro-units (Mitton et al., 2000). The need for microsimulation arises from the difficulty of observing simultaneously the outcomes for the same micro-unit

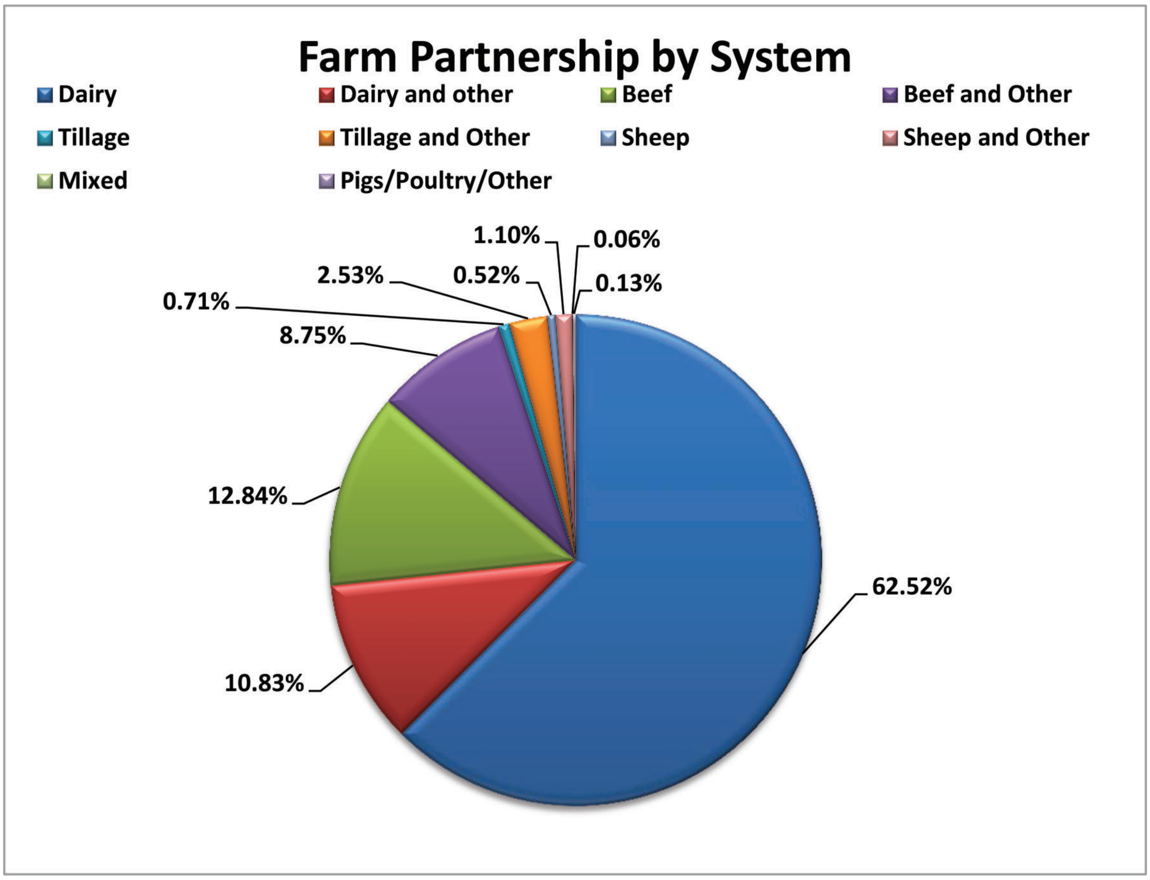

Figure 2: Farm Partnerships in Ireland by System (DAFM, 2017)

under a treatment and in the absence of a treatment (e.g. policy change), and also crucially as a tool to understand the complexity of a policy problem. The result of the microsimulation models can be affected by many factors, which makes it difficult to illustrate the effect of a single factor. Hypothetical models focus on a particular scenario under certain predefined assumptions. This allows the model developer to examine a simplified version of the simulated observation (O'Donoghue et al., 2014). Microsimulation techniques have become a much used instrument for their ability to provide an assessment of differing scenarios and facilitate decision making (Spadaro, 2007). In this case, microsimulation is used to understand economic decisions regarding farm partnership and conclusions will be drawn around the likely follow on implications for farm transfer. Focusing on a hypothetical farm allows for the sensitivity of farms to policies to be tested while avoiding the complications that would arise were this study to be undertaken on a real farm. Farm level decisions are not always rational or economically driven (Vanclay, 2004; Howley et al., 2012), but this method facilitates the simulation of decisions based on economic incentive as opposed to basing decisions on non-economic phenomena.

Modelling different farm partnership scenarios allows for the comparison of outcomes, resulting in the most economically beneficial succession and inheritance scenarios becoming established. Each scenario is in turn affected differently by existing policy and associated legal and financial instruments along with other, more subjective motivating factors (listed on the right hand side of table 1). Table 1 lists the main policies and motivations that will affect each scenario (DAFM, 2015; Lobley, 2010).

Table 1: Main policies and motivations affecting succession/inheritance

Main policies and motivations affecting succession/inheritance	
Policies	**Motivations**
Farm Partnership Tax Relief	Age
Collaborative Farming Scheme	Income
Stock Relief	Health
CAT – Agricultural relief	Reduced work load
CGT – Retirement relief	Increased leisure time
Stamp Duty – Consanguinity relief	Financial security
Young Farmer Top Ups	Education

Base farm characteristics

The hypothetical figures used are average figures from the National Farm Survey (NFS) (presented in table 2). The NFS collects business management information from a stratified random sample of 1,000 farms annually and is part of the Farm Accountancy Data Network of the EU. Average figures for cattle rearing and dairy farms are used for the base farm, as these are the most dominant systems in Ireland, with farmer and successor ages, marital status and qualifications being simulated so that they qualify for maximum capital tax reliefs. For the purposes of testing the efficacy of the simulation model, a base farm without other enterprises (e.g. sheep, poultry, etc.) was used. The addition of sensitivity analysis in future applications of the model to test for the impact of same forms the basis of future research as part of this project. The scenarios to be modelled are described in

Table 2: Average Cattle Rearing/Dairy Data (Teagasc NFS, 2013)

Average Cattle Rearing		Average Dairy	
Family Farm Income	€9,541	Family Farm Income	€62,994
Machinery	€17,717	Machinery	€57,218
Livestock (Breeding)	€26,534	Livestock (Breeding)	€85,569
Trading	€16,855	Trading	€27,867
Land and Buildings	€577,615	Land and Buildings	€973,079
UAA	38.1 ha	UAA	55.4 ha
Total cattle	61	Total cattle	143

Table 3: Farmer/Successor characteristics

Farmer	Successor
Age: 65 Married Pension: Contributory No off farm job	Age: 35 Education: Level 6 Ag. Education Single Off farm job (€25,000 income)

detail later in this section. To ensure each scenario is comparable two base farms are used for this research. In the case of the cattle rearing farms modelled, all farmers qualify for farm assist[8]payment based on low income level.

Farmer and successor characteristics used are outlined in Table 3. These characteristics are applied so that the farmer and successor qualify for maximum capital tax reliefs. A farmer aged 35 or under is considered a young farmer for capital and farm partnership tax reliefs, while a farmer over 65 is considered to be at retirement age and is eligible for a contributory state pension at age 66 (depending on contributions made).

5. Results And Discussion

The outcomes of farm partnership scenarios are illustrated under different policy circumstances in this section, with the scenarios to be modelled described initially. Following this, previous issues involving the farm partnership structure interacting with policies are outlined. Finally, an illustration is given of the microsimulation outcomes with a brief discussion of the results.

Scenarios – format and expected outcomes

The scenarios for this research focus on hypothetical farm partnerships before and after certain policy changes have occurred. As illustrated in table 1, there are a range of motivations and policies affecting the succession and inheritance decision, and many of these will be significant in the hypothetical scenarios. It is expected that scenarios where tax reliefs are optimised will be the most economically beneficial to the farmer and successor. However, income levels should have the biggest effect on policy drivers. Policies aimed at increasing land mobility should minimise land transfer costs and incentivise farmers to transfer land earlier; however, direct payments may make it more economically beneficial for the farmer to delay transfer until death. These payments may

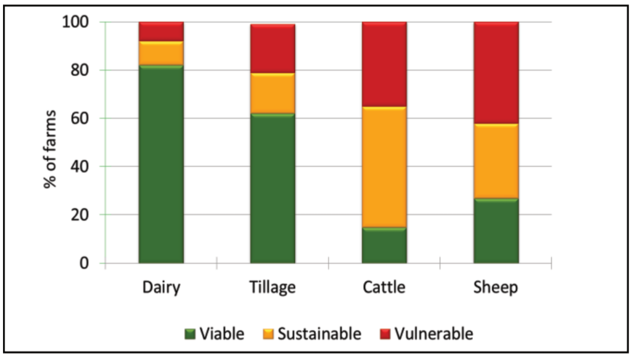

Figure 3: Ireland - Farm Viability by System 2014 (Source: Hennessy and Moran, 2015)

result in land retention by older farmers, as they provide a steady source of income for retirement. Focusing on two hypothetical farms allows for the sensitivity of farms to policies to be tested while avoiding the complications that would arise were this study to be undertaken on a real farm. Variables such as farm size, income and livestock units can be held constant which may not always be the case in reality. Adjusting aspects of the farms will test the effects of succession/inheritance policies on income, in particular the effects of policies surrounding farm partnerships will be investigated.

While farm viability[9] is not the only factor taken into account when making succession and inheritance decisions, a non-viable farm is less likely to be capable of supporting two generations at once as part of a farm partnership. In the Irish case, Hennessy and Moran (2015) note that more dairy and tillage farms tend to be considered viable with beef and sheep farms being more likely to be sustainable or vulnerable (Figure 3), factors which are seen to impact significantly on the results presented in this research.

Routes to succession

As mentioned, there are a range of other possible situations involving farm transfer; however, the two shown here best illustrate the effects of policy changes associated with farm partnerships and how they may have an effect on succession and inheritance processes.

Scenarios modelled

Two scenarios are presented in this section for the farm systems mentioned; these show both a farmer and their successor prior to scheme changes and after scheme changes (described earlier and in this section). The scheme changes here include both proposed future changes and those that have created issues in the past. For all scenarios the farm will be transferred to the successor at the end of a 10 year partnership, with farm income being split 50:50 from the outset of the partnership. The cost of entering a partnership will be borne by the farmer (this cost will be fixed at €2,500 in accordance with the maximum relief available under the SCFG).

Previous disincentives for farm partnerships

In Ireland, there have been policy changes in recent years to facilitate the promotion of collaborative farming and

[8] Farm assist is a social welfare payment for farmers, it is means tested. Here it is assumed that farm income has been the same in the years leading to the beginning of each scenario, thus cattle farmers here will qualify for farm assist payment.

[9] Viable here denotes a farm that has the capacity to pay family labour at the average agricultural wage and provide a 5% return on all non-land assets.

Table 4: Changes to area based payments for partnerships

Changes to area payments for partnerships		
	DAS (2013)	ANC (2015)
Annual payment for partnership (two farmers)	€2,468	€4,936
Annual losses from joining partnership	€2,468	None

allow multiple payments to farmers farming in registered farm partnerships. Unlike the GAEC system in France, formal farm partnerships have not been a prominent feature of Irish agriculture and policy makers have not generally facilitated collaborative forms of farming. In the case of the Rural Environmental Protection Scheme (REPS) and the Disadvantaged Area Payment (DAS) farmers availing of same suffered financially in the following ways if they joined a farm partnership. In the case of Rural Environment Protection Scheme (REPS) payments, partnerships were not catered for in the earlier schemes. If a farmer in REPS entered a partnership with a non-REPS farmer (who did not qualify for the scheme) then both partners would be rendered ineligible. Here a REPS farmer would have to exit REPS and pay back penalties. Changes introduced as part of the REPS IV scheme facilitated multiple payments to registered farm partnerships. Notably, the current Agri-Environmental Scheme (Green Low Carbon Agri-Environment Scheme – GLAS) caters for farmers in partnership to be treated as separate individuals to avoid any loss of payment. For the DAS, the issue was that two farmers in a partnership would only receive one payment. Under the follow up scheme from the DAS, (the Areas of Natural Constraint (ANC) payment) this situation has changed, and farmers are not penalised for being in a partnership (See appendix 1 for further information). Table 4 illustrates the effects of the changes in policy in monetary terms.

Potential benefits

Figures 4 to 7 present an example of potential benefits for average dairy and cattle rearing farmers and their successors where the two parties enter a partnership, the successor here brings 10 ha to the partnership which is being leased. The graphs illustrate 'pre' and 'post' policy changes with pre change not including; higher ceiling of ANC payments, CFGS, or the proposed SFPS, but with post change including these benefits. The contribution of each income component prior to, during and after a partnership is investigated and the graphs show the percentage contribution of each component to overall income. In this way, the importance of changes and their impact on personal income at different stages of the partnership can be assessed.

Dairy farm

The results illustrated in figures 4 and 5 are for a dairy farm before and after scheme changes. The main changes are triggered by the SCFG, SFPS and changes to ANC payments.

On entering the partnership, the farmer's income stream decreases significantly as he/she was receiving all income from the dairy farm. Income taxes also decrease with income stream reduction and decrease further when the farmer reaches age 65 as a result of age benefit[10]. At 66, the farmer is eligible to receive a contributory state pension, meaning this becomes a significant contribution to overall income stream. Post change, the benefit of the scheme changes becomes evident for the farmer as income tax is reduced as a result of the SFPS. After the farm partnership ends and all assets and payments are transferred to the successor, the farmer becomes solely dependent on his/her pension as a source of income. Being dependent on a pension may be an issue in the case of a dairy farmer given the higher level of income they would have received prior to transferrin the farm, thus indicating a disincentive to engage in an arrangement such as this. Based on the level of farm income the farmer in this case is not eligible for Farm Assist. One benefit post change that is not evident in figure 4 would be the benefit of the CFGS. Establishing a partnership would cost €5,000 without the CFGS, while this figure is halved post change.

In the case of the successor, entering the farm partnership means an increase in overall income because they also now have access to the farm income, on acquiring farm income the successor's income tax increases significantly. In the case of post change, the successor has a lower income tax figure due to the benefit of the SFPS. For ANC payment, the successor does not receive their payment on the 10 ha they bring to the partnership pre change, resulting in a loss of €822 per year. Additionally, without the proposed SFPS for the first five years, the partnership incurs €5,000 of income tax for five years that would not be charged under the proposed scheme. This reduction in tax presents an opportunity for farm investment or to begin saving for future investment requirements. In addition to this, the TAMS grant and stock relief stipulations outlined earlier would apply were this partnership to increase herd size or make structural farm improvements.

Cattle rearing farm

The results for a cattle rearing system (figures 6 and 7) differ somewhat from those acquired for a dairy system. On entering the partnership the farmer's income is diminished due to splitting an already meagre income with their successor. In addition, the cost of setting up a partnership pre change decreases income further. The farmer receives Farm Assist as a result of the low income from cattle farming. Similar to the dairy scenario, the farmer is left with his/her pension as the only source of income, however this is comparatively not as significant an income decrease. As with other scenarios, the successor receives half of the farm income and payments when the partnership is entered.

In contrast to the dairy system post changes, the cattle rearing system modelled does not receive the same economic benefit. In fact, there is very little change evident in the figures presented for a cattle farmer. While both parties receive the tax relief, it does not benefit the farmer as much due to their low income tax (stemming from low income level). The SCFG has a positive effect (€2,500) as described for the dairy farmer and the successor receives the tax relief and ANC payment post change as was the case for the dairy farm. Basic Farm Payment remains the same regardless of the year of partnership, this payment may contribute to the farmer

[10] In Ireland, from age 65 a married couple can earn up to €36,000 tax free.

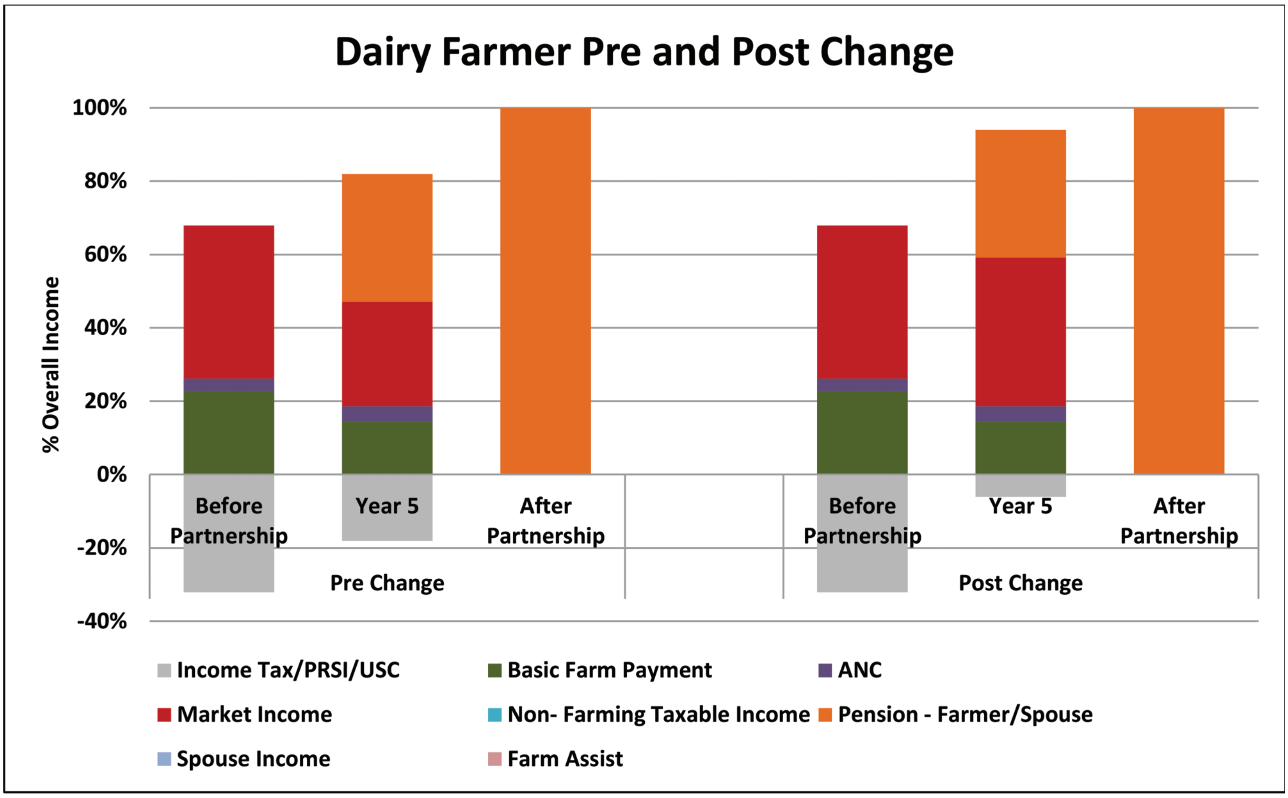

Figure 4: Contribution of farmer income components before, during and after partnership

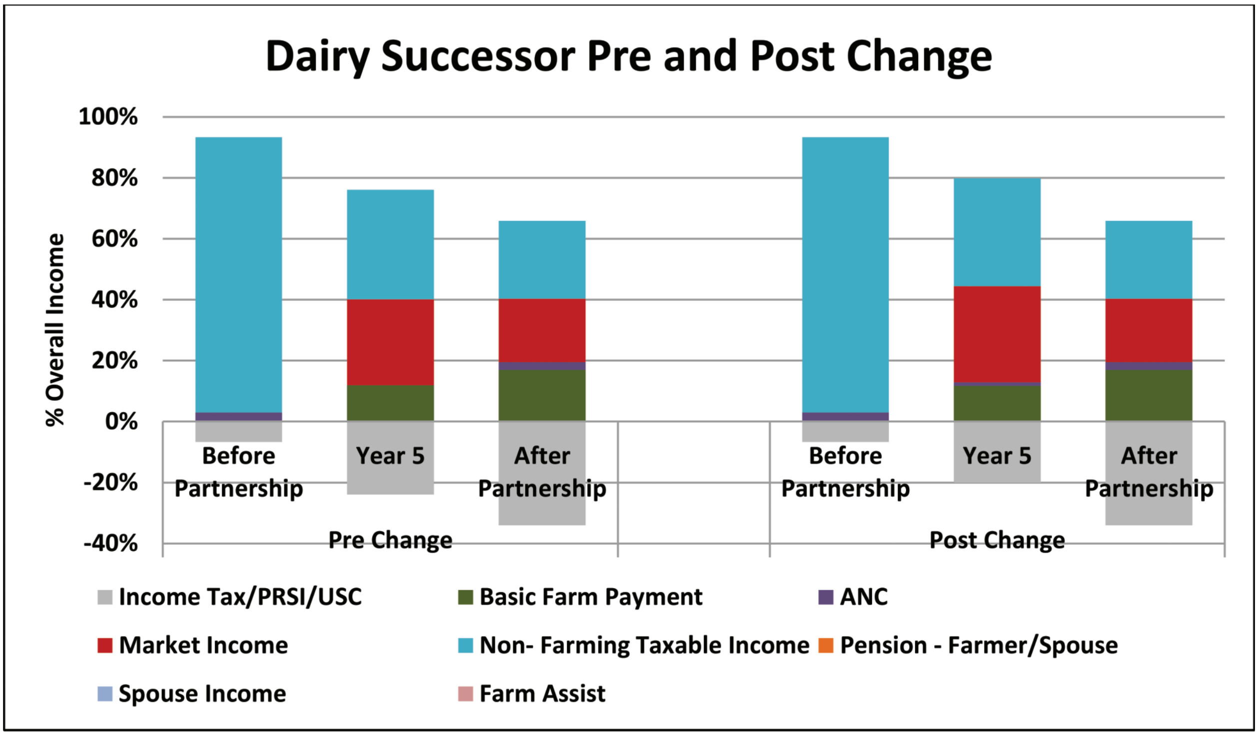

Figure 5: Contribution of successor income components before, during and after partnership

in all cases being reluctant to transfer the farm to their successor. Once the farmer has transferred all assets and payments to the successor, he/she may face financial issues; this, however depends on individual circumstance, as is the case with many aspects of farm succession and inheritance.

Changes to income structure for both the farmer and their successor are presented in the above figures. One main change of note would be the fact that 100% of the farmer's income comes from their pension once the partnership has ended and all farm income is transferred to their successor but this may pose economic issues for

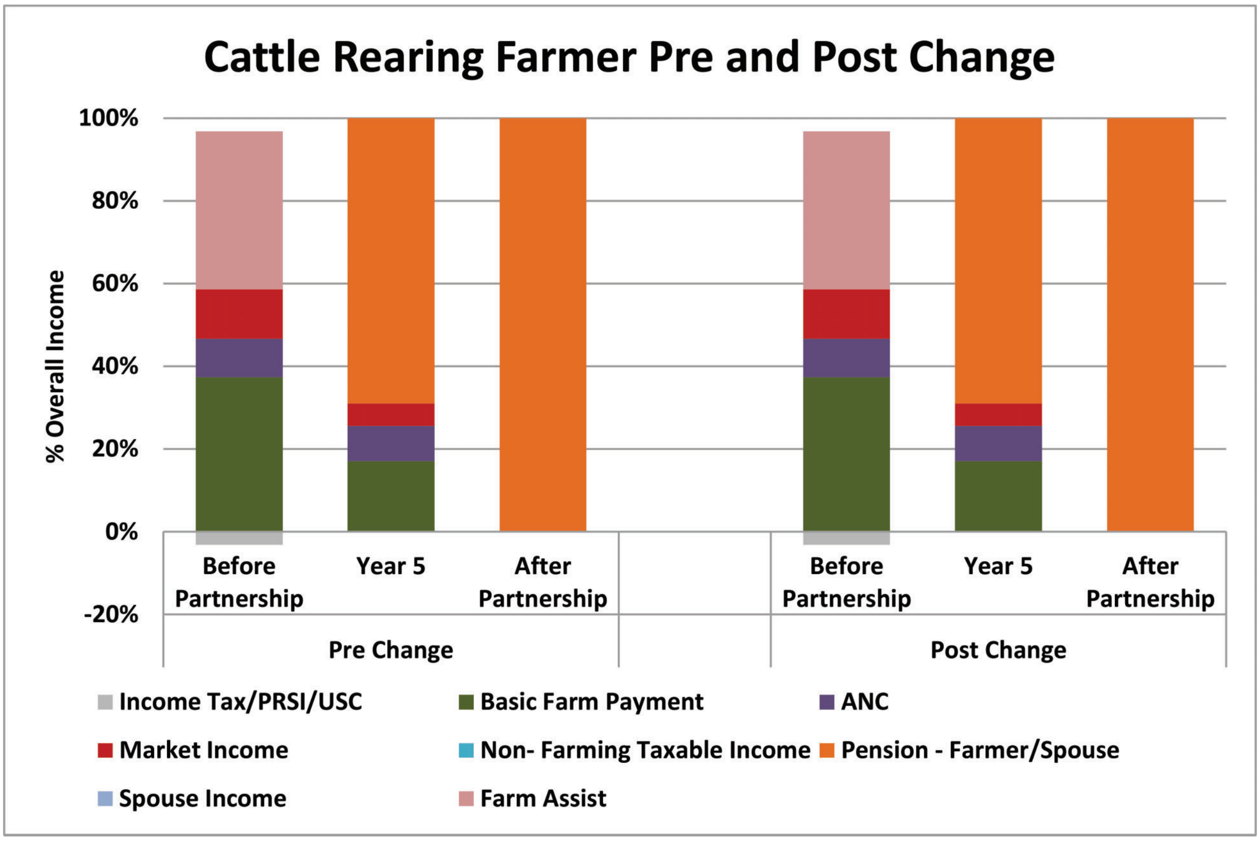

Figure 6: Contribution of farmer income components before, during and after partnership

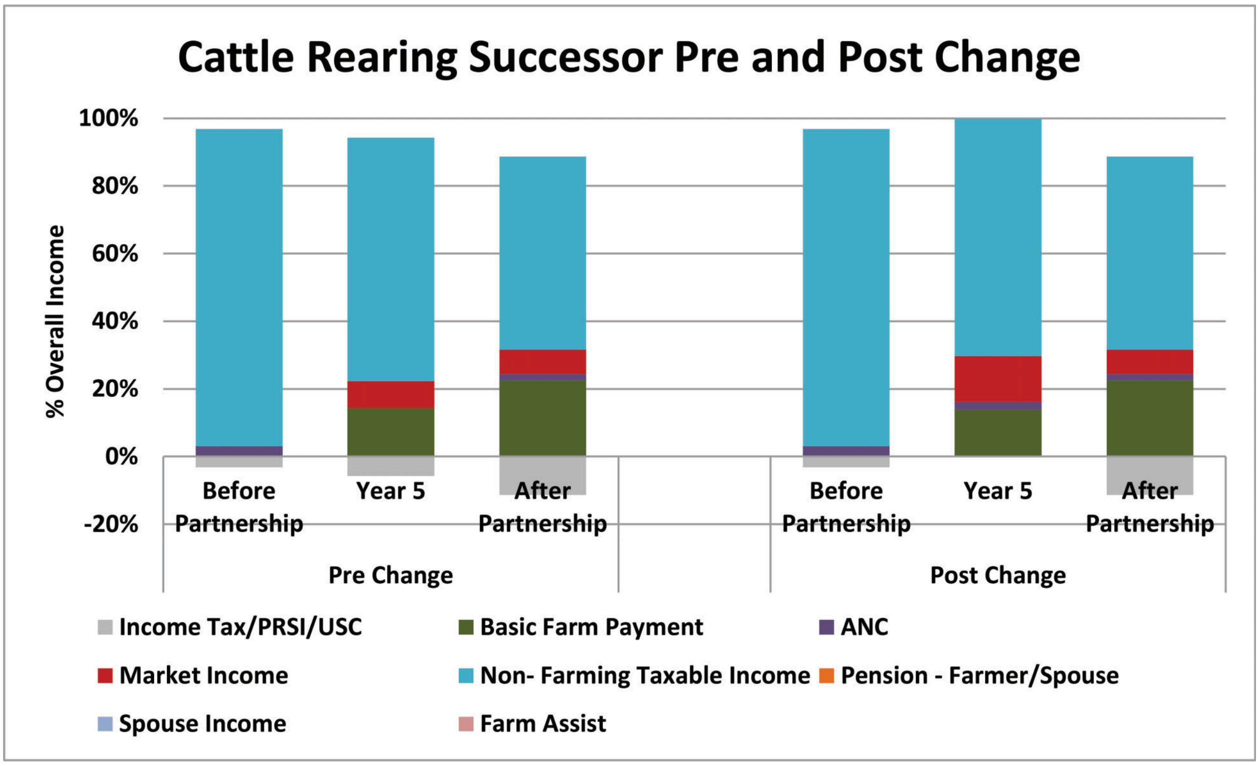

Figure 7: Contribution of successor income components before, during and after partnership

the farmer depending on their costs, but for the successor, the changes that take place regarding income appear as a form of income diversification, with their overall income being enhanced due to the merging of farm income with off farm income. Figure 7 illustrates the benefit of the proposed tax relief for a successor (see appendix 2 for farmer and successor income components in monetary form, graphs illustrating the changes discussed over time are also included).

Issues of farm size and income

In addition to the influence of farm size already discussed, this can also affect the risk preferences of farmers when considering structural changes such as entering a farm partnership. Crowley (2006) asserts that smaller farms will engage in new practices but 'only if there is a high level of confidence that it will not threaten their subsistence' (p. 55), going on to note the higher risk threshold larger farms can afford as a result of their stronger financial situation. Our findings support this argument; farmers on average cattle farms have their subsistence threatened due to the splitting of an already meagre income. In this situation it is assumed that the farmer may perceive a partnership arrangement as a risk to retirement income, particularly where they do not have any source of off-farm income. As mentioned earlier, however, a collaborative farming arrangement may in such cases also reduce the risk of a successor abandoning the family farm. Thus it is also possible to conceptualise the partnership model as a farm survival strategy akin to forms of farm diversification. While farm partnerships may not be financially attractive to cattle rearing farms, the need to gradually exit and allow the entry of a successor into the farm business may be met by such an arrangement. In tandem with this, Ingram and Kirwan (2011) suggest that farm partnerships may provide a suitable means by which older farmers can gradually exit farming. In a partnership farmers may retain levels of control while their successor can also have an influence over decision making. The nature of a farm partnership contract facilitates the staged exit of an older farmer and entry of a young farmer and in this manner a successor may ascend the 'succession ladder'. However, while there are benefits of a non-financial nature associated with farm partnerships beef and sheep systems continue to take a traditional approach to farm succession and inheritance (McLeod, 2012). This indicates that farmers in systems where finances are not as robust may fail to see positive aspects of partnerships. Gasson and Errington (1993) for example describe 'limited farm size with its associated shortage of adequate income and accommodation to support the two generations' (p. 208) as constraints for the formation of farm partnerships. While this may be the case, partnerships for farm systems where off-farm work is the norm may be undertaken for reasons such as those listed earlier (see table 1). Applying this to the findings here, it can be determined that cattle rearing farms need to be made more aware of the non-pecuniary benefits of partnerships.

The differences in average size and income between dairy and cattle rearing systems indicate that dairy systems tend to be larger and more profitable. These factors are likely to be the reason that dairying is the main farm system in which farm partnerships are utilised (McLeod, 2012). The results emerging here concur with McLeod's (ibid.) findings, suggesting that cattle rearing systems are less suited to joining a farm partnership when compared to their dairy counterparts, particularly if the main motivation to become involved in a partnership is economic. It is established in the literature that the characteristics of a farm can have a strong influence on succession and inheritance outcomes, with factors that influence farm income (such as farm size and system) having the most impact on the processes. Uchiyama et al. (2008) found that farm size did influence succession, with successors on smaller farms being more likely to have employment and thus an income source outside of the farm, therefore decreasing the likelihood of them entering farming. Hennessy and Rehman (2007) also found this to be the case in the Irish context. Chang (2013) raises a similar issue when stating that young people have become less interested in farming as a result of the low income that is often accrued from agriculture. The implication is that smaller farms with associated lower incomes will render attracting a successor a difficult task, meaning that the partnership option has very little role to play in the succession process. Larger farms with higher asset values are more likely to be able to identify a successor (Calus et al., 2008). In a study on farm restructuring conducted by Lobley and Potter (2004) which observed a low number of respondents planning to exit farming, the majority of those exiting were older farmers operating smaller farms. The overall implication is that farm size can affect the exit and entry rate, i.e. successors are more enticed to take on larger farms, while exiting farmers are more likely to be leaving smaller farms that are probably financially unviable. Calus et al. (2008) recommend using Total Farm Assets (TFA) as an indicator for farms that will have a successor. While the idea that farm size, value etc. have a positive effect on succession outcomes, using TFA alone as an indicator would not suffice, as it does not capture important factors such as the number of children a farmer has, for example. This is similar to the research findings here, as some of the motivations listed in table 1 cannot be measured.

6. Conclusions

The results presented demonstrate the ways in which the SFPS and SCFG would function, with varying outcomes. In general, the most notable concerns are the relative ability of a farm to generate enough income to support both a farmer and the successor, as well as the residual income of the farmer should they transfer the farm prior to death. In this regard there are clear differences emerging from the simulation exercise that appear to have a strong correlation in the first instance with the type of farm system involved. The proposed tax scheme accrues more financial benefit to successors as they gain farm income from joining the partnership whilst also acquiring the tax relief. However, from the farmer's perspective there is a reduction in farm income, and in the case of cattle rearing systems, tax relief provides little or no benefit. While the introduction of a farm partnership scheme is a positive step towards improved land mobility, successor-centred policy does not adequately address the fact that there are two parties to be catered for in any farm succession and inheritance process. In terms of the SCFG, this provides a minor incentive as it alleviates some costs associated with the setting up of a partnership. The benefit of hypothetical microsimulation as an analytical tool for policy is clear in this paper, with the results illustrating a clear picture of the income components of a farmer and their successor and how they would be affected by policy change. Additionally, the ground level complexities of farm transfer are abstracted allowing for a clear evaluation of proposed and previous changes.

The findings from this research would indicate that there is a rational economic path to be followed towards farm partnership for larger and more financially viable farms, which in turn may facilitate quicker hand-over of farms from an older generation to a younger one. The rationale for undertaking farm partnerships to encourage the exit of older farmers is not apparent, and the merits of the tax relief scheme are otherwise not sufficiently appealing to promote extensive up take at the present time. While the SCFG eliminates half of the associated costs of set up, this may not be a sufficient incentive to enter a collaborative arrangement. The recommendations from this research would be for more wide-ranging enquiry into the ways in which the tax relief scheme would generate broader appeal, along with a series of recommendations on how this would be implemented. This may involve two strands of further research; the first would entail a qualitative study regarding farmer and successor perceptions of policy aimed at encouraging farm transfer. Second, a follow up quantitative study investigating other less prominent farm systems and the implications policy changes may have at farm level in terms of encouraging engagement in farm succession and inheritance processes. As it stands, its impact on the major policy concerns of an ageing farm population and associated implications for farm efficiency and agricultural productivity will be minimal. In the case of cattle farms, there is potentially an argument to be made for creating a scheme that provides an economic incentive beyond tax relief for farms of this nature; this would in turn have financial implications that would require more extensive research. Additionally, the consultation of individuals who fully understand the practical and administrative aspects of introducing new schemes is advised at the early planning stages of scheme rules and details. This could be realised in the form of small stakeholder groups participating in the design of such policy initiatives to ensure that issues of collaborative farming interacting with future policy change are minimised.

The main findings from this research indicate that farm partnerships are to some extent a suitable means by which to expedite farm succession and inheritance; however, this statement comes with some caveats. The suitability of a partnership depends on the individual farm level situation and also on what expectations the farmer/successor has for a partnership. Based on the findings from this research, deciding to enter a partnership based solely on an economic rationale is best suited to dairy systems, while cattle rearing farms may have a propensity to focus on benefits such as the gradual transfer of control and increased leisure time afforded to partners. These wider non-economic benefits that could potentially be generated through farm partnerships, which could in turn bring a shift in mind-set about the value of earlier farm transfer, require further research and wider dissemination of information on same. This is especially important in the case of farmers' operating systems where budgetary constraints are present.

In summary, facilitating a sector-wide increase in farm succession and inheritance will require a higher level of understanding of different farm systems and the way in which partnerships as part of this process can aid these farm businesses in the first instance, and facilitate timely farm transfer in the second. Based on the results from this research, current policy does not provide a suitable financial benefit for farms that face higher levels of income uncertainty (in this case cattle rearing systems). Finally, as the farm partnership scheme is in its infancy an appraisal of the scheme is required to ensure it is effective in encouraging farm succession and inheritance.

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Acknowledgements

The authors are grateful to the Royal Dublin Society and the Teagasc Walsh Fellowship Programme for funding this research. In addition to this the authors would like to thank Avril Claffey (Department of Agriculture, Food and the Marine) for her input into this paper. The authors are grateful for the comments of two anonymous reviewers.

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Appendix 1

During 2015, initial issues arose for ANC payments interacting with farm partnerships, caused mainly due to technical problems. At an administrative level, for farms to enter a partnership (where partners both have a herd prior number) typically, one herd number would become 'dormant' on the Department of Agriculture, Food and the Marine (DAFM) registration system. In this instance only one herd number associated with a partnership could meet the qualifying criteria and therefore no payment issued to the partnership. This issue has been resolved for 2016 by applying the qualifying criteria at partnership level rather than at individual partner level. The changes now allow for multiple payments to issue from 2016 onwards. A similar technical issue arose in terms of the Basic Payment Scheme (BPS) entitlements, farmers joining a partnership would have entitlements merged making it very difficult to exit a partnership at the end of the agreed time period without financial loss (see below for working example). This has also now been resolved to ensure that when farmers dissolve their partnership, they can take back their entitlements in the same fashion as they first contributed them.

Additionally, technical issues prevented farmers in farm partnerships obtaining multiple payments in the previous Disadvantaged Area Scheme (DAS). Under the scheme, a farmer operating in his own right would attract one payment on up to a maximum of 30 hectares. When two farmers who were drawing area based payments entered into a MPP they were then reduced to one payment threshold, likewise with three farmers. Only one payment was achievable under the scheme and consequently farmers entering registered partnerships were at a financial loss by entering partnership. Similar to agri-environmental payments, existing disadvantaged area payments (now 'Areas of Natural Constraint' – ANC) also cater for partnerships allowing multiple payment thresholds where two farmers are in partnership (i.e. max. of 60 ha for a partnership with two partners). Table 4 illustrates the potential losses from area based payments not facilitating farm partnerships[11].

Example

Farmer A farmed 40 hectares and owns 40 entitlements worth €850 each (€34,000).

Farmer B farmed 50 hectares and owns 50 entitlements worth €250 each (€12,500).

They entered into partnership and all 90 hectares was farmed under one herd number and the partnership claimed all entitlements.

If they cannot establish separate set of BPS entitlements in 2015, a situation arises where all entitlements

[11] This example of based on a maximum of 30 ha for a 'Less Severely Handicapped' area (€82.27 per ha).

are averaged out (that means the partnership will receive 90 BPS entitlements worth €516.60 each or a total value of €46,000.

Without separate set of entitlements, a serious issue arises when these farmers want to dissolve their partnership in the future. They will be faced with two choices, (i) divide out on the basis of total value or (ii) by the number of entitlements.

(i) If they divide the payments on the basis of total value, then Farmer A would receive 65.81 entitlements (worth €34,000) but he only has 40 hectares available to claim them. Therefore he is left with insufficient land. Farmer B would receive 24.19 entitlements (worth €12,500) and he is left with 25.81 hectares with no entitlements.

(ii) If they divide the payments based on the number of entitlements then Farmer A would receive 40 entitlements worth €20,664. He would suffer a loss or reduction in the value of his entitlements of €13,336. Farmer B would receive 50 entitlements worth €25,830. He would gain €13,336 at the expense of Farmer B.

(iii) Either way, there is no satisfactory division of entitlements on the dissolution of the partnership. This will prove to be a strong deterrent to farmers entering partnership.

(iv) It also means that they can only qualify for one ANC payment even though they are both eligible as individuals (as in the real case study further on).

(v) It is unclear whether there is an implication of a doubling of the investment ceiling under TAMS II.

(vi) This may lead to legal issues (court action) in the future if they cannot recover their entitlements in an equivalent fashion to joining the partnership.

NOTE: The fundamental principle of two farmers forming a partnership is that they can dissolve it in future without any conflict and recover the assets licensed into the partnership for its' duration. The new BPS system must embrace this principle to the fullest extent and be capable of achieving this or it will sound the death knell for farmers joining partnership. Farmers will not go into partnerships if they think there is the possibility of their entitlements being merged with their partners.

Appendix 2

Table 5: Dairy Farmer Income Components Years 1 and 5 of Partnership

Year	Pre/ Post	Income Tax/ PRSI/USC	Basic Farm Payment	ANC	Market Income	Non- Farming Taxable Income	Pension - Farmer/Spouse	Spouse Income	Farm Assist	Cost of Set Up	Tax Credit Received
1	Pre	€-7507	€8277	€2468	€14368	€0	€0	€0	€0	€-5000	€0
1	Post	€-5007	€8277	€2468	€19368	€0	€0	€0	€0	€-2500	€2500
5	Pre	€-10431	€8277	€2468	€16444	€0	€20011	€0	€0	N/A	€0
5	Post	€-3502	€8277	€2468	€23373	€0	€20011	€0	€0	N/A	€2500

Table 6: Dairy Successor Income Components Years 1 and 5 of Partnership

Year	Pre/ Post	Income Tax/ PRSI/USC	Basic Farm Payment	ANC	Market Income	Non- Farming Taxable Income	Pension - Farmer/ Spouse	Spouse Income	Farm Assist	Tax Credit Received
1	Pre	€-16659	€8277	€0	€19677	€25,000	€0	€0	€0	€0
1	Post	€-14159	€8277	€823	€22177	€25,000	€0	€0	€0	€2500
5	Pre	€-16659	€8277	€0	€19677	€25,000	€0	€0	€0	€0
5	Post	€-14159	€8277	€823	€22177	€25,000	€0	€0	€0	€2500

Tables 5 and 6 present the fiscal values associated with the graphs presented earlier, this provides a ground level image of the components that effect the farmer and successor income pre and post changes at the beginning and during a partnership. The reduction in tax for both parties is notable here, with the tax relief providing a strong economic incentive.

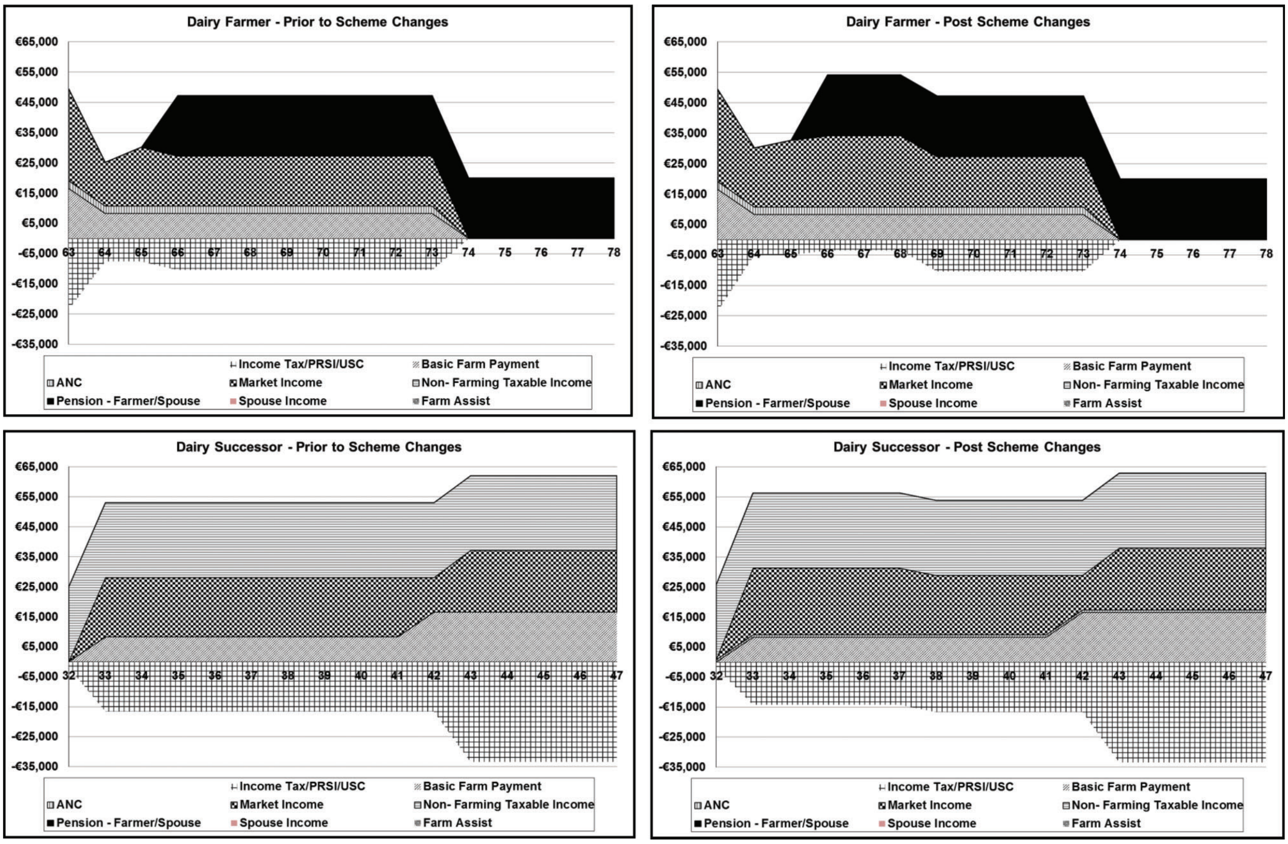

Figure 8: Dairy Farmer and Successor Pre and Post Scheme Changes. The graphs above illustrate the impact of scheme changes over time together with future changes. The main differences occur when a partnership is entered, here; this is when the farmer is aged 65.

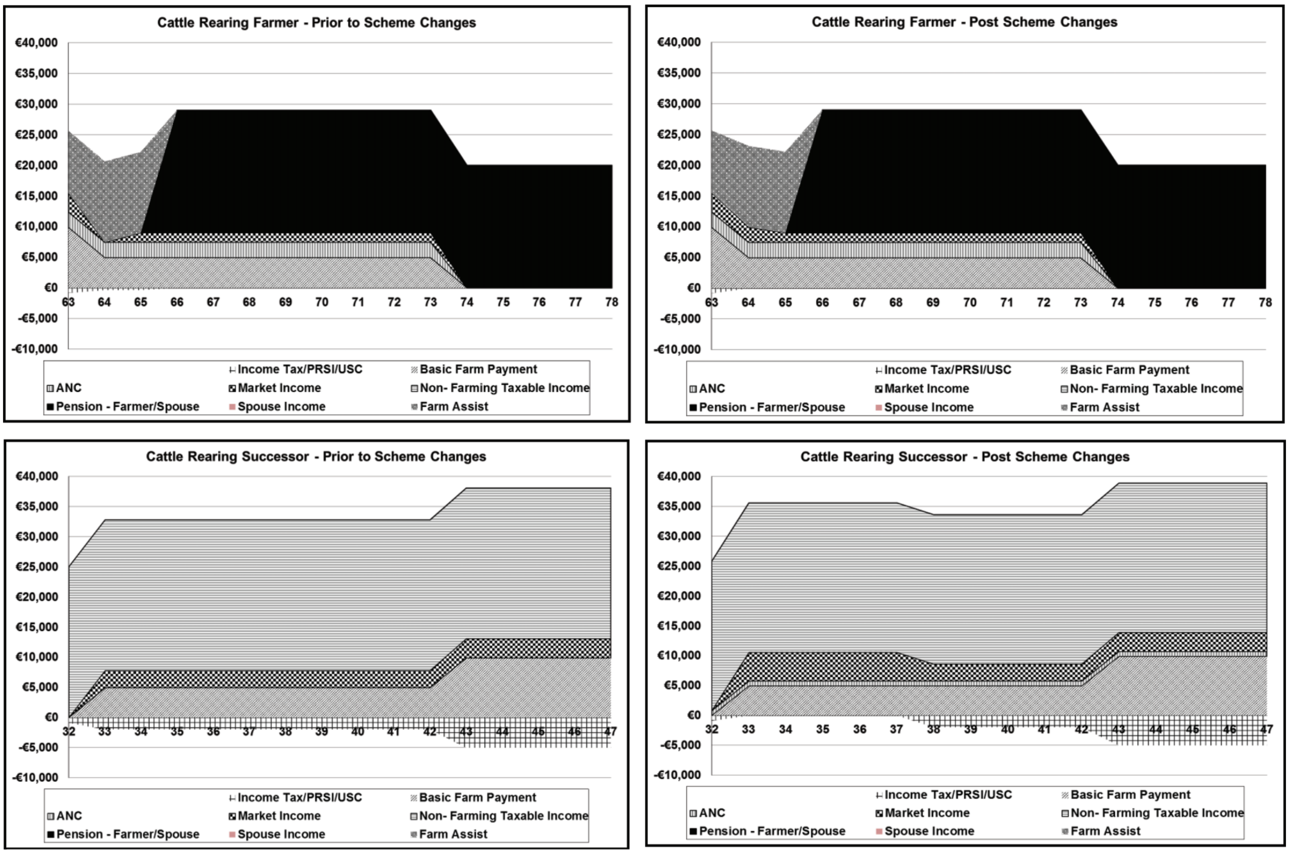

Figure 9: Cattle Rearing Farmer and Successor Pre and Post Scheme Changes. The graphs above illustrate the impact of scheme changes over time together with future changes. The differences between pre and post scheme changes here are less prominent in comparison to dairy scenarios.

REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-20

The Whole farm financial implications of different tillage systems on different crop rotations in the Swartland area of the Western Cape, South Africa

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ABSTRACT

A Conservation agriculture (CA) is one of the most holistic sustainable agricultural practices yet. It reduces environmental degradation, and concurrently it could enhance farm profitability. A large proportion of the commercial grain producers in the Middle Swartland in the Western Cape Province of South Africa have adopted CA to varying degrees. Adoption of CA in South Africa, has taken place in the absence of any policy support framework directed to CA.

The physical/biological benefits of CA are well known. The financial implications of the various systems within CA, at farm-level varies. Farm systems are complex, consisting of numerous interrelated components, and different farmers' views, preferences and skill sets. A whole-farm budget model is developed within a systems approach to compare various farming systems designed within CA principles. Multidisciplinary group discussions are used to bridge the gap between disciplinary scientific knowledge. To serve as a basis for comparison, the whole-farm model was based on a typical farm within the Middle Swartland relative homogeneous farming area.

The financial evaluation of the various farming systems showed that conventional agricultural practices of monoculture and deep tillage are financially unsustainable. The financial benefits of CA are directly related to improved soil health, lower weed and pest stress and improved yields. The CA farming systems were less susceptible to variations in external factors, highlighting the resilience of the system that incorporates crop rotation and no-till.

KEYWORDS: Conservation agriculture; sustainability; systems thinking; budget modelling; resilience; no-till

1. Introduction

Conservation agriculture (CA) is promoted as an important holistic practice of sustainable agriculture and has experienced high adoption rates across the globe since the mid 1990's (Derpsch and Friedrich, 2010). Conservation agriculture rests on three guiding principles; continuous minimum soil disturbance, permanent organic soil cover, and diversified crop rotations (FAO, 2010). The practice promotes sustainable management of natural resources while increasing agricultural productivity and sustaining the farmer's livelihood, resulting in poverty alleviation and food security (Friedrich and Kienzle, 2007). Every farm has a unique set of ecological characteristics. The guiding principles of CA provide a foundation from which the producer can build a more sustainable farming system according to that unique environment (Knowler and Bradshaw, 2006).

Initial adoption of minimum disturbance and eventually no-till practices were farmer driven and their decisions were based in stewardship of the land. The large scale adoption in the Swartland production area was however based on two key drivers. Firstly, following the deregulation of marketing and the consequential abolishment of the different commodity control boards, farmers were forced to find ways to reduce input costs and remain viable (Vink *et al*, 2011). Secondly, the prevalence of herbicide resistant ryegrass compelled farmers to adopt crop rotations so they could use grass herbicides in the broad leaf cropping phase. No-till planting equipment also enabled farmers to spray one effective herbicide, Trifluralin (Strauss, personal communication, 2014).

Successful conservation agriculture adoption varies throughout South Africa and southern Africa (Thierfelder *et al.*, 2012). The Western Cape and Swartland

Original submitted July 2016; revision received November 2016; accepted December 2016.
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(see Appendix 1) is a typical Mediterranean climate region and ideal for winter cereal production. The adoption rate of CA in wheat production systems in this area is relatively high.

Producers appreciate the ecological and economic value of adopting crop rotations. However, the whole-farm financial implications of adopting a CA tillage practice are not well known. Adopting CA tillage requires high capital investment within the system, especially in commercial agriculture, as new machinery is required, equipped with GIS, automated steering, depth control and yield censoring equipment. Decker *et al.* (2009) reported that the no-till machinery prices were nearly double that of conventional machinery. The aim of this paper is to determine the financial implication of the combined effect of tillage and crop rotation systems on farm level over an extended period of time.

2. Materials and Methods

In support of conservation farming, trails are being carried out at Langgewens Experimental farm in Middle Swartland (see Appendix 1). Soils are predominantly Malmesbury and Bokkeveld shales, with a long-term average rainfall of 396.9mm (Wiese, 2013). Two parallel trials are run, one focuses on tillage practices and the other of crop rotation systems. By using the data from both trials, it is possible to gain a more accurate simulation of practical farming systems taking place in Middle Swartland and the associated costs. The four different systems included in the study are:

- Wheat, wheat, wheat, wheat (WWWW)
- Canola, wheat, wheat, wheat (CWWW)
- Wheat, canola, wheat, lupins (WCWL) and,
- Wheat, medic, wheat medic (WMWM).

Yields and production data were recorded on each specific crop (to represent a crop phase in the system). The production activities include; land preparation, planting, fertilization, crop protection and harvesting. The relevant prices of inputs used in each year were also recorded and is based on what producers would pay. An enterprise budget model was built for each crop to evaluate the production cost and gross margins of the different systems.

Conservation agriculture advocates increased yields through rotations in two ways. Firstly, increased yields experienced due to rotations with other crops (Nel *et al.*, 2003; Chikowo *et al.*, 2004; D'Emden *et al.*, 2006; Upendra *et al.*, 2009; Thierfelder and Wall, 2010; Nel and Lamprecht, 2011; Kassam *et al.*, 2012) such as legumes (medics and lupins), and also non-legume crops like canola. Secondly, by suppressing grass weeds in the broadleaf crops. Rye grass is a weed prevalent in the Middle Swartland area. Both wheat and rye are grass varieties; subsequently there are limited herbicides that can control one without affecting the other. Broadleaf weeds are better controlled during years of cereal production and grass weeds during years of broadleaf crop production. This also effectively reduces the prevalence of herbicide resistant weeds. Wheat monoculture achieved the lowest and most erratic yields in the Langgewens Crop Rotation trials, situated in Middle Swartland area, over the 2007 to 2013 period, competitive rye grass being identified as a causal factor.

Initially producers feared a loss in income with the introduction of broad-leaf cash crops, such as canola, and legumes, such as lupins, into the crop production system. Alternatively, legume pastures associated with sheep production can be implemented. The market for canola, introduced in 1996 in the Western Cape, has grown sufficiently to establish canola as a financially viable cash crop. Improved agronomic practices, suited to the specific environment in Middle Swartland, and better canola seed varieties (resulting from improved selection through canola cultivar trials across multiple testing sites around the production area) increased the attractiveness of canola as a rotation crop and a cash crop.

Reduced cost is generally experienced in crop rotation systems, as opposed to wheat monoculture (Sorrenson *et al.*, 1996; Lange, 2005; Llewellyn *et al.*, 2009; Crabtree, 2010; Piggen *et al.*, 2011). Wheat monoculture is relatively more erratic in terms of non-directly allocated cost, resulting in a lower cumulative gross margin as shown in Figure 1.

Systems Analysis and Whole Farm Budgeting

The challenges that producers face require short-term tactics as well as medium to long-term strategies. The study of these challenges is complicated by the gaps in expert knowledge, typically created by specialization and gaps between academic and practical knowledge. Multidisciplinary discussions provide a platform to bridge this gap. This requires the involvement of various participants including; researchers, producers, agribusinesses, advocacy groups and private consultants (Power *et al.*, 2011). This allows research to collectively identify actionable solutions that incorporate the dynamics of the whole farm, generate a realistic whole farm model and simulate more real world scenarios.

With computer technology, budgets can be adapted to accommodate more multi-faceted systems (Nuthall, 2011). Using spreadsheet programs, whole farm budget models can handle complex calculations and relationships, yet are adaptable and user-friendly. This classifies the budgeting technique as simulation based on accounting principles. Multi-period, whole-farm budget models can calculate the Internal Rate of Return on capital investment (IRR) and Net Present Value (NPV) (Hoffmann, 2010).

For the purposes of this research, a typical farm, that is representative of the Middle Swartland grain farm, model was developed to provide a basis of comparison for the expected impacts of specific systems and possible external impacts. A typical farm is defined as a farm representing what a group of farmers do within an essentially homogeneous area (Feuz and Skold, 1992). This was applied to assess the crop trial results on the whole farm level. The whole-farm structure was validated by expert stakeholders such as scientists, producers, and economists during a multidisciplinary workgroup discussion. The farm was initially defined with the inputs of local extension officers. The budget model, firstly, determines the current financial position of the typical farm. Secondly, it is used to compare the financial implication of alternative production systems and thirdly, evaluate the profitability impact of exogenous variables in the form of scenarios. Standard accounting principle was followed within the standard structure of whole farm budgets.

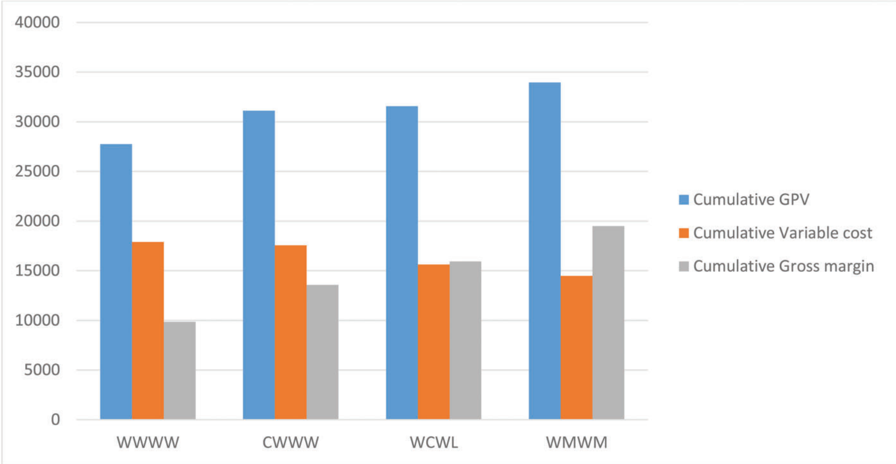

Figure 1: Cumulative gross production value (At the time of writing (mid-June 2016), R1.00 was approximately equivalent to $US0.07, £0.05, €0.06.), variable cost, and gross margin per system from the Langgewens Trials, for period 2002-2011

The expert group suggested Langgewens research farm as the basis for defining a relatively homogenous area. Characteristics defining a homogeneous area include; climate, terrain and soil type, and farming practices. The climatic conditions in this area are characterized by rainfall between 250-450mm in the winter between April and mid-October, with typically dry hot summers. The soils are predominantly Malmesbury shale, consisting of shallow sandy-loam soils. The area is a traditionally wheat producing area with rotations of canola and lupins. Medic pastures for sheep are also rotated with wheat.

A representative farm serves as basis to which farmers in a homogeneous area can relate. This is done by mimicking a farm on the most common physical farm parameters found in the area. Within the whole-farm model, the typical farm size determines; area cultivated, land utilization, mechanization, labour requirements, and investment in fixed improvements. The expert group agreed on a typical farm for the Middle Swartland area, as shown in Table 1.

The expert group considered and agreed to the structure and values of the typical farm. This includes land and fixed improvements, movables, and sheep. The investment in sheep is determined by the land under pasture and stocking rate. The composition of the herd is derived from assumptions on ram to ewe ratio and the ewe replacement policy. The output values for the sheep enterprise were obtained from local agribusiness and the Langgewens trial data. The value of the herd, including rams, ewes, replacement ewes and lambs were obtained from local agribusiness and experts in sheep husbandry.

The crop rotation systems that were included in the group discussion were accepted as the three most commonly practiced crop rotation systems used in the Middle Swartland and compared to wheat monoculture. Wheat still forms the basis of the rotations used in the Middle Swartland and all the systems maintain at least half the area under wheat cultivation. Tillage can influence both yield and variable cost to the enterprise. The traditional form of tillage known as conventional tillage (CT) is compared to the increasingly popular No-till (NT) practice advocated by CA.

Crop yields vary due to seasonal variations. To incorporate this risk factor into the model, the prevalence of good, average and poor years were identified. Rainfall scenarios for the Middle Swartland were obtained from local weather stations and personal communication with producers and local agribusiness extension officers. It was found that despite a number of good seasons from 2011, the prevalence of good, average, and poor years would likely still follow the same pattern as identified in a previous study (Hoffmann, 2010). Good, average, and poor years are caused by dispersion of rainfall throughout the season and influence the profitability of the whole-farm over an extended period of time. Each of the three seasonal variations can be defined as follows:

- A good year: represent the ideal rainfall conditions to provide the crop with sufficient water throughout the growing season.
- An average: adequate total annual rainfall, however the dispersion would be disruptive to plant growth, for example, there may be insufficient rainfall to establish the crop or at seed filling time, resulting in reduced yields.
- A poor year: both erratic rainfall dispersion and a low annual total rainfall, resulting in low yields. This includes the prevalence of droughts.

Yield data, presented during the expert group meeting for discussion, were derived from production guidelines combined with data from the Langgewens crop rotation trials (Strauss, 2013 and Labuschagne, 2013). The expert group confirmed the expected yields in Middle Swartland for good, average, and poor years as well as the expected frequency within a ten-year period. The key yield assumptions provided by the expert group are highlighted in Appendix 2.

Wheat yield for both no-till (NT) and conventional tillage (CT) in a poor year is 1600kg/ha as shown in Appendix 2. The benefit of moisture retention in NT is traded off with the benefit of mechanical weed control

Table 1: Physical description of typical Middle Swartland farm

Homogeneous Area	Middle Swartland
Typical farm size (ha)	800
Land Price R/ha	30,000
% Arable Land	95%
Ha Arable Land	760

in CT. Soil moisture retention is mitigated by rainfall dispersion in average and good years; therefore wheat yields under CT outstrip yields under NT.

Under a rotation system with legumes, wheat yields are higher than in a monoculture system because of nitrogen fixation in the rotation, and more effective weed control. Improved weed control trough rotation, results in benefits of no-till being realized such as soil moisture retention and improved soil structure and fertility. The result is higher yields under NT than under CT. The relative benefit of soil moisture retention declines as rainfall patterns improve in average and good years.

The benefits of the crop rotation system also apply to the WMWM system, shown in Appendix 2. The additional increase in wheat yield compared to the LWCW system is attributed to the enhanced nitrogen fixing properties of medics compared to lupin and canola, a non-legume crop. Medics have shallower root systems and re-establish themselves in the following year, thereby reducing traffic on the field and further exaggerating the effect of reduced tillage on soil structure and fertility.

Cropping canola in the rotation system shows similar increased yields in the following wheat crop as lupins and medics do, even though canola is not a legume. The improvement in the yield of wheat following a canola crop might be attributed to better grass weed control which lowers seed bank numbers that could compete with the following wheat, the crops taproot system helps to improve water infiltration and possible phosphorus mobilisation. Canola offers a financially viable alternative cash-crop to rotate with wheat. Appendix 2, Table 4 shows the consecutive wheat yields following canola. Increases in wheat yield directly following canola crops follow the same trend as seen in Appendix 2, Table 2. The second consecutive wheat crop in the rotation records an increase in yield of 14 percent on a typical wheat monoculture crop. The third consecutive wheat crop should see an 8 percent increase on a typical wheat monoculture crop (Hoffmann, 2011 and Strauss, 2014). Thereafter, wheat yields begin to decline.

Appendix 2, Table 5 shows the yields of canola and lupin validated during the group discussions. The expert group agreed that these crops would follow similar trends under the different tillage practices as the wheat crop with higher yields under no-till as compared to conventional tillage.

Sheep were brought into the crop production systems of the Middle Swartland area for diversification purposes. Sheep were included at standard practices and composition as determined by the group. Bias was more towards performance of the crops.

Analysis of financial vulnerability through scenarios

A scenario is a hypothetical description of a possible future (Therond *et al*., 2009), or the variation in the assumptions used to create models (Peterson *et al*. 2003). Scenarios are widely used in research to assess the impact of 'what if questions'. For instance; 'what will the impact of whole-farm profitability be if the wheat price decreased by 10 percent?' Under normal circumstances, in the event of declining commodity prices, producers are likely to substitute one crop for another. For the purpose of this research a *ceteris paribus* principle is factored into the scenarios. *Ceteris paribus* in economic terms refers to the effect of one economic variable on another, while holding all other variables constant.

The model can depict the impact of changes in various assumptions on whole-farm profitability. The scenarios included are; increased input prices, declining wheat price, and devaluation in the Rand to the US dollar raising the price of machinery and fuel.

Model Variables

The data consist of various attributes of each item used as an input in the production process. These attributes include; brand name, unit of sale, recommended application rates per hectare for the product, and the unit price. Product prices were derived of a three-year average of input prices from Langgewens research farm (2011-2013). If product prices were not available, a three-year average was taken from industry.

The output price used in the model was derived from a three-year average price of the specific commodity. The price of wheat was derived from the three quality grades, B1, B2, and B3. A typical blend of quality per ton was obtained from local agribusiness and study group data. The running costs and purchase price of machinery was incorporated using the 'Guide to machinery costs' recently developed and released by local agribusinesses in the Western Cape (Guide to machinery costs, 2014). The expert group agreed on the mechanisation requirements.

The main difference between the farm inventories, for the various farming systems in the model, occurs with the wheat medic rotational system. In the wheat/medic system 50 percent of the arable land is under wheat and the remaining 50 percent under medic pastures. The machinery requirements differ as medics re-establish themselves in the year following wheat. The result is a lower kilowatt requirement and smaller implements can be used. The input costs contributing to total variable costs remained the same irrespective of the seasonal performance. This excludes silo costs, which are determined by the yield.

3. Results

The first set of trial data focus specifically on soil health and adopted a blanket effect of all production activities above the surface including machinery movement, soil disturbance, cover crops and grazing. As a result, the crop yields are very erratic and in some instances, where weeds have out-competed the wheat, yields were not recorded. This makes it very difficult to directly analyse the financial outcomes of the cropping systems as the trials were not designed or intended for economic analysis. What does stand out from the financial analysis is the evidence of reduced input costs and increased yields under crop rotations, refer to Figure 2 and Table 2. This is in line with the principles of CA.

Figure 2 shows the average non-directly allocatable costs for the three tillage practices; no-till (NT), minimum-till (MT), and conventional-till (CT), under the three rotation systems, based on the Langgewens crop trials. There are two sets of data for the rotation of wheat, canola, wheat, lupin (WCWL). The two graphs depict wheat following canola (LWCW), and wheat following lupin (CWLW). Below the non-directly allocatable cost graph, is the corresponding average gross margin for the same crop within the crop rotation and tillage practice. It is clear evidence of a reduction in non-directly allocatable costs. This is because CA tillage practices constitute lower mechanical costs due to less movement over the field.

The second set of Langgewens trial data comprises crop rotation trials that began in 1996 and are still active. This research highlighted four of the rotations being trialled, namely wheat monoculture (WWWW), wheat, lupin, wheat, canola rotation (WCWL), wheat, medic rotation (WMWM), and canola, wheat, wheat, wheat rotation (CWWW). Wheat monoculture achieved consistently lower yields than wheat in rotation. In 2003 the Western Cape experienced a severe drought resulting in wheat planted in the 4 cash crops systems not being harvested. Since the system is based on a cash crop sequence and does not have an animal factor the resulting residue was not grazed. The only harvestable wheat crop was that of wheat in rotation with medics. The yield and input cost data was captured in enterprise budget models designed to relate the physical input/output quantities into gross margins. Figure 3 shows the gross margins per hectare achieved under each crop rotation system. The consistent yields and low input costs of wheat in rotation with medics are depicted in a less erratic curve.

Gross margin analysis

The budget model calculates a gross margin for each crop under both no-till and conventional-till practices, as well as a whole-farm gross margin for both practices, across all the crop rotation systems. The gross margin is calculated by subtracting the variable costs of production from the gross production value.

Table 2 shows the whole-farm gross margin and gross margin per hectare for the different crop rotation systems and under differing tillage practices. The data used for calculating the gross margins presented in Table 2 was obtained from the Langgewens crop rotation and Langgewens tillage trials. Physical inputs and yields were calculated from 2002 - 2012 trail data.

Whole-farm financial performance

The budget model measures the profitability of the typical farm over a 20 year period. The financial performance is measured in the internal rate of return on capital investment (IRR) and net present value (NPV) of the future expected cash flow. The IRR and the NPV are calculated

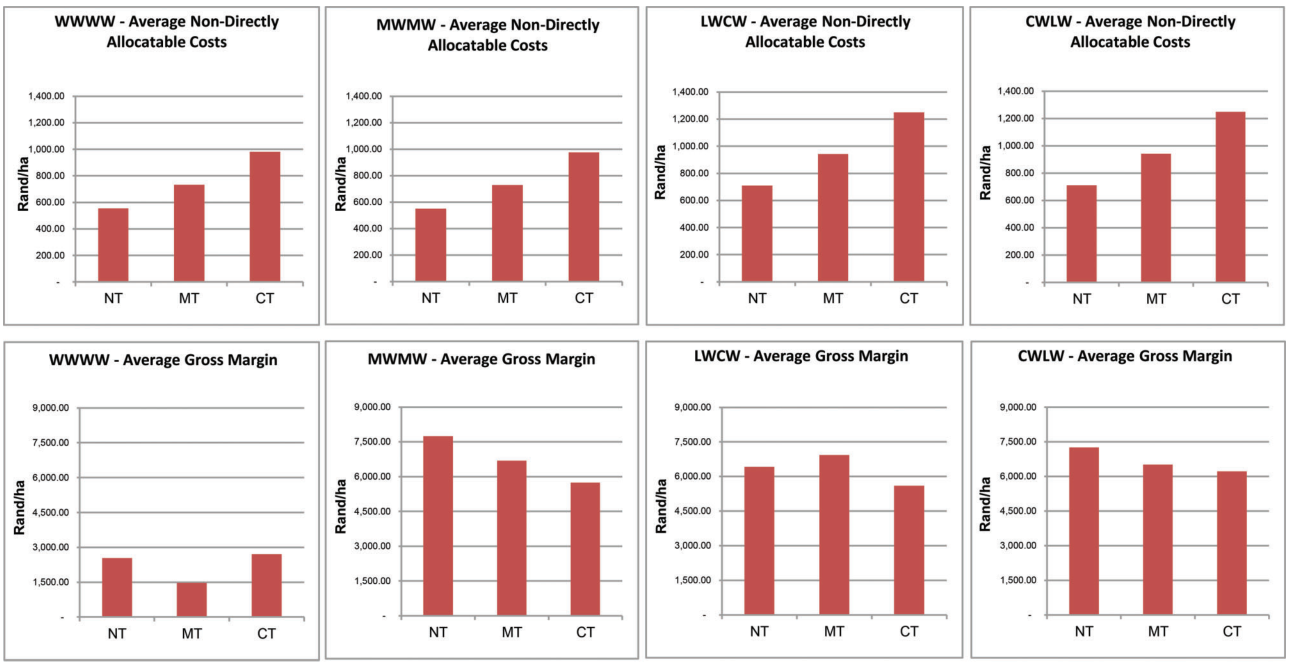

Figure 2: Trends in the non-directly allocatable costs and the gross margins of crop systems

Table 2: Total gross margin for good, average, and poor seasons for each crop rotation system

Crop Rotation System	Tillage Practice	Gross margin for whole-farm and gross margin per hectare					
		Good year		Average year		Poor year	
		R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
WWWW	NT	4 089 682	5 381	2 611 622	3 436	693 556	912
	CT	3 857 682	5 075	2 165 879	2 849	37 041	48
WCWL	NT	4 705 670	6 191	3 119 248	4 104	1 249 319	1 643
	CT	3 994 159	5 255	2 193 995	2 886	245 357	322
WMWM	NT	4 386 982	5 772	3 537 951	4 655	2 370 532	3 119
	CT	3 803 974	5 005	2 742 684	3 608	1 681 395	2 212
CWWW	NT	5 122 049	6 739	3 444 471	4 532	1 330 071	1 750
	CT	4 269 781	5 618	2 272 330	2 989	248 742	327

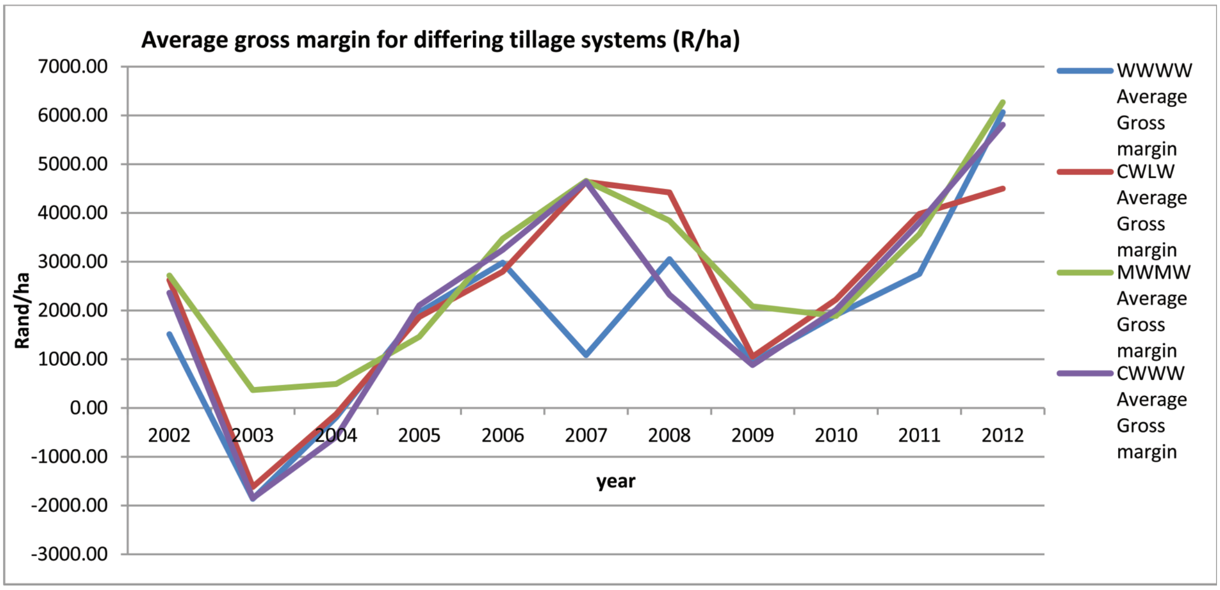

Figure 3: Average gross margins (R/ha) of different crop rotation systems from 2002-2012

for each farming system, which includes the rotational system and tillage practice. The IRR and NPV are calculated in the whole-farm multi-period budget sheet.

Table 3 shows the NPV and the IRR for each of the crop rotation systems under the different tillage practices over a 20 year period. The average nominal interest rate was 9.0 percent, the inflation rate 6.1 percent, and the real interest rate 2.73 percent (Statistics South Africa, 2014, and South African Reserve Bank, 2014).

When the IRR falls below the real interest rate (2.73%), the NPV moves into a negative value, as the investment over a 20-year period will yield a negative return. Table 3 shows that all of the farming systems practicing conventional tillage return an IRR below the real interest rate and a resultant negative NPV. These options are consequently unattractive to investment. In the case of wheat monoculture (WWWW), the farming system under both no-till and conventional tillage practices, renders a negative NPV and an IRR below the real interest rate. Wheat monoculture is therefore unattractive to investment irrespective of tillage practice. Wheat monoculture production under conventional strategies degrades soil over time due to excessive tillage, while under no-till production the weed management becomes a problem due to the development of herbicide resistance over time.

The WCWL system's profitability suffers as lupins do not generate a viable market price and yields are erratic. Despite a positive effect on wheat yields following lupin, the poor gross margin of the lupin enterprise decreases the whole-farm profitability under this crop rotation system. The WCWL system was included in this study because it is part of the Langgewens trials. Other legumes such as chickpeas and fava beans could have been used as an alternative, but was not available to use at the initiation of the trials and the lupins was thus kept to ensure the integrity of the long term trial.

Wheat in a medic (sheep) rotation (WMWM) is the only system that offers a higher IRR under conventional tillage. The reason is that in the agronomical research there was no conclusive evidence that a pasture system under no-till would increase the output of the sheep enterprise. There is little evidence to support a higher stocking

Table 3: The net present value (NPV) and internal rate of return on capital investment (IRR) for each typical crop rotation system

Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)
WWWW	NT	2.24%	R -2 028 333
	CT	1.29%	R -5 812 838
WCWL	NT	4.06%	R 5 425 665
	CT	1.39%	R -5 449 243
WMWM	NT	4.69%	R 7 981 843
	CT	2.56%	R -712 778
CWWW	NT	5.39%	R 10 684 593
	CT	1.93%	R -3 241 267

rate of sheep on medic pastures following wheat. Pastures, in a good year, would generate larger quantities of grazing for sheep, it is difficult for the producer to predict the weather in time and buy or sell sheep accordingly. Additional supplementary feeds can be bought in poor years; however, there is no research on this to support assumptions on feeding levels. For this reason, the output generated from sheep on medic pastures is kept constant irrespective of tillage practice or seasonal variations of good, average, and poor years.

Furthermore, under the mixed crop/sheep rotation system, the producer is unable to take full advantage of a really good year because half of the area available for crop production is under pastures. Therefore, although the WMWM rotation may enjoy the buffer effect in a poor year, the limitations in a good year result in a lower IRR potential for the whole-farm system.

The CWWW rotation system records the highest IRR and NPV of the four rotation systems. The reasons for this are; firstly, the producer is able to take full advantage of a good year because all the rotation crops in the system generate a high gross margin. Canola is a profitable cash crop and the benefits of the crop rotation generate high yields for wheat following canola when compared to wheat monoculture. As expressed in Appendix 2, Table 5, the benefits of wheat following canola are not limited to the first year but also benefit subsequent years of wheat cultivation, although at a diminished rate. Secondly, the benefits increased yields under no-till further enhance the profitability of the system.

Further to this, the reason the CWWW system records a negative and subsequently a relatively high gap in profitability between no-till and conventional-till is because the system lacks a buffer effect in the poor years, enjoyed by the WMWM system.

Increasing input cost

The first scenario assessed the profitability impact of an increase in input costs. This was aimed at determining the impact of input price inflation on the typical farm for each of the different systems. Fertiliser, chemicals, and fuel, contribute the largest components of the variable costs. A simulated increase in input costs of 10 percent, 20 percent, and 30 percent was used to evaluate the impact on the IRR. The results of the simulation are shown in Table 4. The current situation is depicted in the left four columns under 'Whole-farm model'. The columns to the right under the title 'Rising input cost scenario' show the IRR in the event of a percentage change in input prices. The relative change in the IRR is the percentage change between the current IRR and the new IRR.

Firstly the significance of tillage is highlighted. Table 4 shows that, compared to a conventional tillage system, the no-till system is less susceptible to rising input prices. Under conventional tillage an increase in input prices results in double the relative change in the IRR (74 percent) as compared to the relative change in the IRR under no-till (33 percent). Conventional tillage reduces organic matter and carbon levels in the soil making it more input intensive. An estimated 50 percent more nitrogen is required to produce the crop than under no-till practices.

A conservation agriculture system, of combined no-till and crop rotation, shows less than half the relative change in the IRR compared to a conventional system as affected by rising input prices. Table 4 shows that the worst performing crop rotation system is wheat, canola, wheat, lupin (WCWL) under no-till in terms of relative change in the IRR. A 10 percent rise in input prices to the system shows a 15 percent relative change in the IRR. A wheat monoculture system (WWWW) under conventional tillage shows a relative change in the IRR of 74 percent. This highlights the buffering effect of increased yields, generated by rotations in the cropping system, to the impact of rising input prices.

Lower wheat price

Table 5 shows that a 10 percent decline in the wheat price would cause an expected 35 percent relative change in the IRR, for the most profitable farming system (CWWW). This is more than double the relative change in IRR for the same system (CWWW, 13 percent) in the event of a 10 percent rise in input costs. This system (CWWW) is expected to experience a relative change in the IRR of 35 percent, a decrease in the IRR to 3.53 percent in the event of a 10 percent decline in the wheat price. It is expected that a 30 percent rise in input prices could have a similar effect to the systems IRR, decreasing it to 3.37 percent.

In the WMWM system, only 50 percent of the area is under wheat. More importantly, the wheat yields are more stable and higher than that of the wheat in the monoculture system. The impact of declining wheat prices is consequently expected to be less in contrast to the wheat dependent systems. Table 5 shows that the expected effect of a 10 percent decline in wheat price, results in a lower relative change in the IRR for the WMWM system as opposed to the CWWW system. The actual IRR remains lower at 3.22 percent as opposed to 3.53 percent respectively. After a 30 percent decline in wheat price, the WMWM system records an actual IRR of 0.37 percent while the CWWW system falls into a negative IRR at -0.07 percent. This shows that the WMWM system is less susceptible to declining wheat prices.

Machinery cost as impacted by exchange rate

The group discussions expressed concern over the continued devaluation of the Rand to the US dollar and the potential increase in cost of replacing machinery. The price of planting equipment required for CA is high, therefore the aspect of path dependence and subsequent narrowing of options due to the high investment requirements in creating production capacity in winter cereal systems, can be highlighted. Adopting CA is not a straightforward decision because the financial implications of potentially reduced income during the initial phases of adoption are compounded by the large capital investment

Table 4: Relative percentage change in IRR as a result of an increase in input costs.

Whole-farm model				Rising input cost scenario					
				10% ↑		20% ↑		30% ↑	
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333	1.50%	33%	0.76%	66%	0.03%	99%
	CT	1.29%	R -5 812 838	0.33%	74%	-0.62%	148%	-1.55%	220%
WCWL	NT	4.06%	R 5 425 665	3.45%	15%	2.84%	30%	2.23%	45%
	CT	1.39%	R -5 449 243	0.64%	54%	-0.11%	108%	-0.85%	161%
WMWM	NT	4.69%	R 7 981 843	4.14%	12%	3.60%	23%	3.05%	35%
	CT	2.56%	R -712 778	1.95%	24%	1.26%	51%	0.58%	77%
CWWW	NT	5.39%	R 10 684 593	4.71%	13%	4.04%	25%	3.37%	37%
	CT	1.93%	R -3 241 267	1.06%	45%	0.21%	89%	-0.64%	133%

Table 5: Relative percentage change in the IRR as a result of a decline in the wheat price

Whole-farm model				Wheat price decline scenario					
Wheat R2 792.87/ton (3 year average, 2011-2013)				10% ↓	R 2 514	20% ↓	R 2 234	30% ↓	R 1 955
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 3337	0.22%	90%	-1.76%	179%	-3.70%	265%
	CT	1.29%	R -5 812 838	-0.83%	164%	-2.90%	325%	-4.93%	482%
WCWL	NT	4.06%	R 5 425 665	2.69%	34%	1.33%	67%	0.00%	100%
	CT	1.39%	R -5 449 243	0.13%	91%	-1.12%	180%	-2.34%	268%
WMWM	NT	4.69%	R 7 981 843	3.22%	31%	1.78%	62%	0.37%	92%
	CT	2.56%	R -712 778	1.25%	51%	-0.12%	105%	-1.46%	157%
CWWW	NT	5.39%	R 10 684 593	3.53%	35%	1.71%	68%	-0.07%	101%
	CT	1.93%	R -3 241 267	0.24%	88%	-1.41%	173%	-3.03%	257%

Table 6: Relative percentage change in IRR as a result of an increase in base costs of machinery and fuel

Whole-farm model				Rising fuel and machinery cost scenario					
				10% ↑		20% ↑		30% ↑	
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333	1.84%	18%	1.45%	35%	1.08%	52%
	CT	1.29%	R -5 812 838	0.89%	31%	0.50%	61%	0.12%	91%
WCWL	NT	4.06%	R 5 425 665	3.64%	10%	3.23%	21%	2.83%	30%
	CT	1.39%	R -5 449 243	0.99%	29%	0.61%	56%	0.24%	83%
WMWM	NT	4.69%	R 7 981 843	4.38%	7%	4.07%	13%	3.77%	20%
	CT	2.56%	R -712 778	2.33%	9%	2.02%	21%	1.72%	33%
CWWW	NT	5.39%	R 10 684 593	4.93%	9%	4.49%	17%	4.07%	24%
	CT	1.93%	R -3 241 267	1.51%	22%	1.11%	42%	0.72%	63%

required to purchase the necessary machinery. This can have a significant impact on the cash flow of the business and profitability. The rising costs of machinery may deter potential CA adoptees. They would instead continue producing conventionally. This research shows that conventional practices are not viable in the long term, and that CA poses the best option for reducing costs to increase profit.

One of the greatest savings from adopting CA has been the reduction in; kW power requirement, repairs and maintenance on machinery, and fuel (Bignell, personal communication, 2014). Conservation agriculture reduces soil tillage. Therefore, less power is required to establish a crop.

Increases in the price of machinery and fuel of 10 percent, 20 percent, and 30 percent was simulated to evaluate the impact on the profitability. Table 6 shows the actual and relative changes in the IRR in the event of rising fuel and machinery costs. The conventional system shows significantly higher relative expected changes to the IRR when compared to the systems under conservation agriculture (WCWL, WMWM, CWWW).

The WMWM system operates with a lower total inventory value, as only 50 percent of the area is under cash crops, therefore requiring fewer and smaller capacity machinery. The WMWM system subsequently experiences the lowest relative change in the IRR.

4. Conclusions

The Middle Swartland is traditionally a well-known wheat production area in South Africa, but is challenged by relatively erratic rainfall patterns and shallow soils. To support sustainable farming practices various crop rotation and tillage practices are being researched at Langgewens experimental farm in the Middle Swartland. A multi-period budget model, supported by multidisciplinary group discussions, was developed to firstly, establish the current profitability of the typical farm, and secondly to evaluate the impacts of variations in the external environment. The dynamics of the model allow it to incorporate the complication of interrelationships between variables within the whole-farm system. This model was used to determine the current profitability of the typical farm under various crop rotation systems and tillage practices to establish the expected profitability of each farming system.

Three scenarios were selected from issues raised during the group discussions and included; rising input costs, declining wheat price, and rising machinery and fuel costs. A lesser impact is expected, based on wheat price, on the profitability of the farming systems with wheat in rotation with canola, lupins, and medics/sheep when compared to the monoculture system. The rotation systems are diversified into various crops, the impact of a decline in a single commodity price would not be as significant as for the monoculture system. The increased yields generated from the crop rotations and no-till also offer a buffering effect in the event of declining wheat prices.

The effect of an increase in input prices has a greater impact on conventional tillage systems that are input intensive. The increased yields in the rotation systems and under no-till serve as a buffer against the effect of inflation on input prices. In the case of increased machinery and fuel costs, the WMWM system was least affected. Only 50 percent of the area cropped was under cash crops, which means less mechanical and fuel requirements.

All the crop rotation systems performed better in terms of profitability than the wheat monoculture system. This is due to the combine effects of increased yields, lower costs and diversification of crop rotations. All the systems under no-till are expected to be more profitable than the systems under conventional. This is caused by the benefits from reduced input costs and mechanical investment. Overall the CA system with crop rotation combined with no-till has the highest expected profitability over the 20-year period. It is still uncertain what the implications of different sheep production systems might contribute to profitability as well as the impact of cover crops. Those two factors should be included in future research.

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Acknowledgements

The authors are grateful to the Western Cape Agricultural Trust for the financial assistance that made this project possible.

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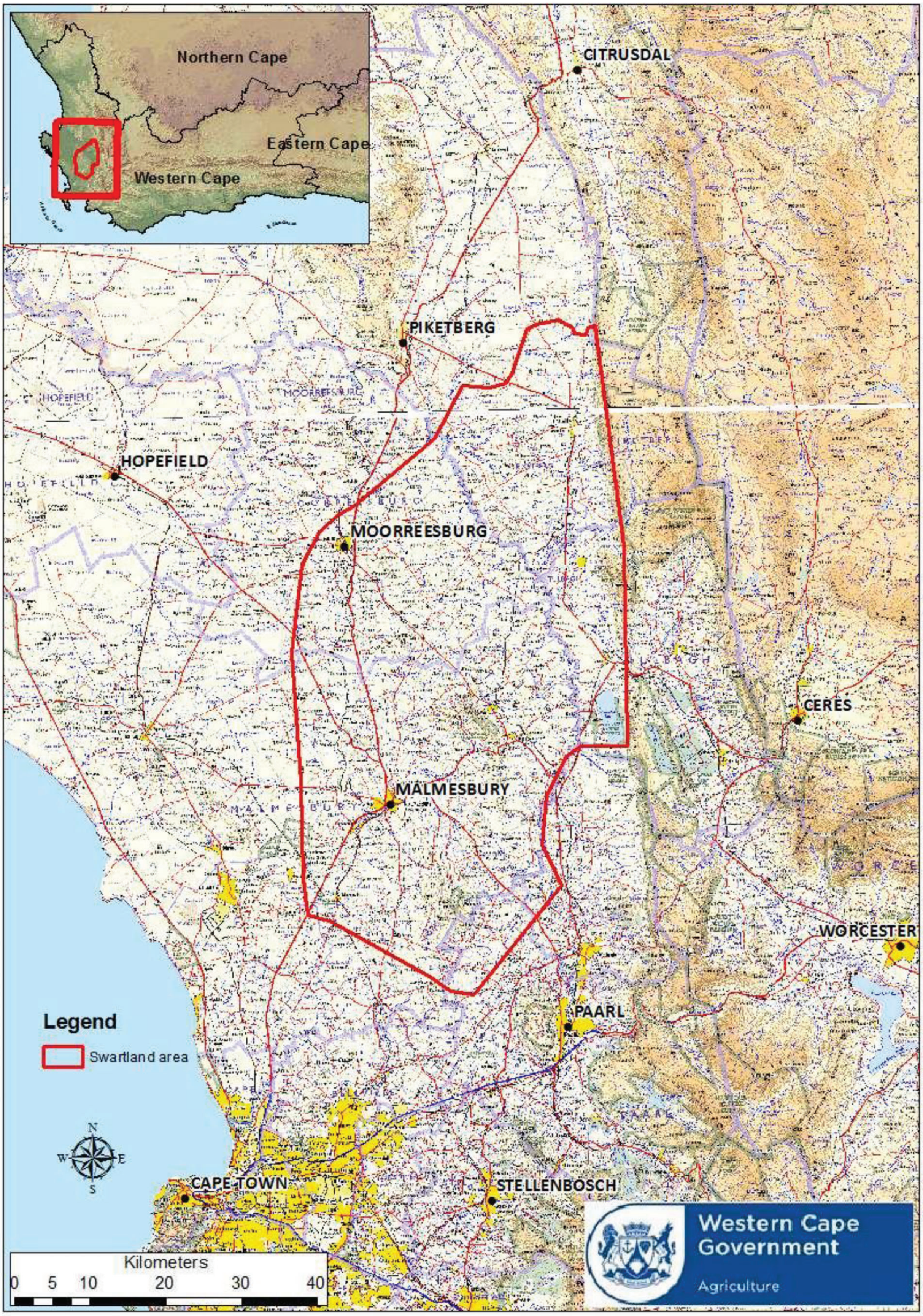
Appendix 1

The Western Cape and Swartland



Appendix 2

Table 1: Wheat monoculture yield values and frequency validated by the expert group discussions

WHEAT YIELDS		EXPERT GROUP VALIDATED YIELD VALUES/HA	
CROP SYSTEM		**WHEAT MONOCULTURE (WWWW)**	
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	1,600	1,600
AVERAGE YEAR	7	2,500	2,600
GOOD YEAR	1	3,200	3,400

Table 2: Wheat/Canola/Lupin rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS		EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM LUPIN, WHEAT, CANOLA, WHEAT	
CROP SYSTEM		**(LWCW)**	
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	2,350	2,100
AVERAGE YEAR	7	3,400	3,100
GOOD YEAR	1	4,100	4,000

Table 3: Wheat/Medic rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS		EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM WHEAT, MEDIC, WHEAT, MEDIC	
CROP SYSTEM		**(WMWM)**	
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	2,500	2,200
AVERAGE YEAR	7	3,600	3,200
GOOD YEAR	1	4,400	4,200

Table 4: Wheat/Canola rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS		EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM WHEAT/CANOL ROTATION (WCWW)					
CROP SYSTEM		**CWWW 8%**		**WCWW 14%**		**WWCW**	
TILLAGE PRACTICE	**Frequency**	**No-till**	**Conventional-till**	**No-till**	**Conventional-till**	**No-till**	**Conventional-till**
POOR YEAR	2	1728	1600	1824	1624	2350	2100
AVERAGE YEAR	7	2700	2400	2850	2550	3400	3100
GOOD YEAR	1	3456	3356	3648	3548	4100	4000

Table 5: Canola and lupin yield values and frequency validated by the expert group discussions

CANOLA YIELDS		EXPERT GROUP VALIDATED CANOLA YIELD VALUES KG/HA FOR SYSTEM WHEAT, LUPIN, WHEAT, CANOLA	
CROP SYSTEM		**(WLWC)**	
TILLAGE PRACTICE	**FREQUENCY**	**No-till**	**Conventional-till**
POOR YEAR	2	800	700
AVERAGE YEAR	6	1,400	1,300
GOOD YEAR	2	2,000	1,900

LUPIN YIELDS		EXPERT GROUP VALIDATED LUPIN YIELD VALUES KG/HA FOR SYSTEM WHEAT, CANOLA, WHEAT LUPIN	
CROP SYSTEM		**(WCWL)**	
TILLAGE PRACTICE	**FREQUENCY**	**No-till**	**Conventional-till**
POOR YEAR	2	700	600
AVERAGE YEAR	6	1,300	1,200
GOOD YEAR	2	2,000	1,900

DOI: 10.5836/ijam/2017-06-32

Economic benefits of extending the grazing season in beef cattle production in Atlantic Canada

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ABSTRACT

Today, feeding cost is a significant issue for the economic viability of livestock operations, including beef production. The aim of this study was to determine, in comparison to the conventional feeding approach, the advantages and expected value of extending the grazing season in Atlantic beef production using stockpiled and baled forage. The research methodology is based on the partial budgeting approach. The study shows that extending the grazing season can reduce by 54% the total annual production cost for feed, yardage and straw bedding. Indeed, this innovative feeding approach can contribute to avoiding expenses of $7,331.92 per farm per year through eliminating and/or reducing overwintering costs for feed (16%), yardage (55%) and straw bedding (29%). A detailed analysis shows a saving of $0.92 of the overwintering production costs per cow/calf pair per day. Moreover, extending the grazing season does not seem to compromise animals' performance. This practice could therefore be an alternative solution to enhance beef farm financial viability and can also contribute to the sustainable development of beef farms through other services provided such as recreation functions and environmental protection. These results reflect the necessity of supporting and promoting the adoption of extended grazing season practices in Atlantic beef production.

KEYWORDS: beef production; extending the grazing season; economic benefits; Atlantic Canada

1. Introduction

Many research studies have been done in Canada related to grazing systems and how they could be better employed for cattle feeding. Particularly in Western Canada, several research studies focused on beef feeding strategies are trying to determine how beef production could be conducted more economically and sustainably by reducing production costs and environmental impacts (Kaliel, 2004; Baron *et al.,* 2014; Baron and McCartney, 2014). These research studies show that innovative feeding strategies under the general description of 'extending the grazing season' can be an alternative solution to enhance beef farm viability in Canada. However, extending the grazing season is used less in Atlantic beef production, where farmers continue to employ a conventional feeding approach, which consists of raising animals on pasture during summer and feeding them in the barn the rest of the year. Beef production researchers and specialists are currently conducting research on extending the grazing season in Atlantic beef production, while taking into account the unique weather conditions in the region.

Indeed, in Canada, as in many developed countries, government support to agricultural production remains one part of farmers' income. One reason for this may be the incapacity of livestock systems to be financially autonomous and could be due to low return on investment in a context of high operational production costs, including feed cost (Lachapelle, 2014). The viability issue in livestock farming may also stem in part from environmental issues (Arsenault, Tyedmers and Fredeen, 2009), animal welfare (Martelli, 2009; Harper and Makatouni, 2002), food quality concerns (Boval and Dixon, 2012) and the perception of livestock production in society (Beauchemin *et al.,* 2010). This study will mainly focus on the financial viability issue.

Animal feed represents the largest input cost for livestock and poultry producers, up to 75 percent of the total cost depending on the species. The use of production systems with low or lower feeding costs could therefore

Original submitted August 2016; revision received January 2017; accepted January 2017.

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contribute to improved financial viability of livestock farming. Particularly in beef cattle production, the efficient use of grazing systems with good management practices can contribute to reduced production costs and enhanced beef farm viability in Canada (Kaliel, 2004; McCartney *et al.,* 2004). In fact, extending the grazing season in beef cattle production can eliminate feed storage and manure removal and spreading costs, reduce the use of tractors, reduce labour cost for animal feeding and improve soil fertility (Baron *et al.,* 2014; Kaliel, 2004; McCartney *et al.,* 2004).

This study aims to integrate economic, forage agronomy, and livestock production data to determine the economic costs and benefits of management techniques that extend the grazing season for Atlantic beef producers. In turn, this information allows us to identify which feeding system is most efficient for Atlantic beef farm viability; the efficiency of a system or a plan being its capacity to allow output at a lower cost.

2. Background on Approaches to Extending the Grazing Season

According to D'Souza *et al.* (1990), extending the grazing season is a management system in which the usual grazing season is lengthened by utilization of hay fields for pasture. It may also consist of the use of the stockpiling of perennial forages (Peterson *et al.,* 2001). Extending the grazing season increases the number of days animals are fed on pasture and reduces the number of feeding days in the barn. This approach requires the herd manager to take early actions to identify and plan the appropriate strategies; it cannot be an impulsive decision to leave the animals grazing for a longer period of time. In Canada, the different strategies to extend the grazing season can be grouped under three main methods: stockpiled grazing; swath grazing; and bale grazing.

Stockpiled grazing is summer forage regrowth which is saved for use as fall and winter pasture. It may replace part or all of the hay, straw or silage needed for winter feeding of beef cattle and can be an important part of a cattle producer's production system (Baron and McCartney, 2014). The stockpiled grazing method requires very low inputs through elimination of costs related to harvesting of hay and reduced labour for feeding and manure handling. Stockpiled grazing is economically interesting in the sense that animals feed themselves and also spread manure themselves, which means a considerable saving on labour and machinery costs (Hamilton, 2012). However, the use of the stockpiled grazing method is limited in time, in the sense that it is not beneficial to stockpile the forage for a long period before the animals consume it. Indeed, if left for a long time before grazing, the stockpiled forage loses its nutritive quality in response to growth and emergence of fibrous elements (Perennia, 2010), and in response to rain and snowfall during winter. Stockpiled grazing presents benefits in Atlantic Canada to extend the grazing season at low cost in a part of the year where rain and snowfall are not very frequent, usually from mid-autumn to early winter.

Swath grazing is another management practice that can be used to extend the grazing season and reduce feed, labour and manure handling costs for cattle producers. Swath grazing is practiced more commonly in Western Canada, where it is considered as the main method to extend the grazing season and reduce cattle overwintering costs (Baron *et al.,* 2014; Baron *et al.,* 2012). However weathering caused by late fall and winter precipitation, in conjunction with snowmelt, substantially reduces the nutritive value of swathed material (Aasen *et al.,* 2004). For this reason, in Atlantic Canada, where rains are very common during autumn and winter, swath grazing is less suitable as a method to extend the grazing season.

Bale grazing is the practice of placing large quantities of bales out for livestock in the fall and regulating access and intake during the winter. It is also called extensive bale grazing, in contrast to intensive bale grazing which consists of feeding animals with baled forage in a confined area. If swath grazing appears to be the main method of extending the grazing season in Western Canada by reason of its productivity and nutritive value (Baron *et al.,* 2014), bale grazing appears to be the method of choice for extending the grazing season in the Atlantic region. Indeed, in Atlantic Canada, bale grazing has the most benefits as it is mostly likely to maintain forage nutritive value during winter. The relative benefits of the three methods, in Atlantic Canada, are summarized in Table 1 below.

In general, the stockpiled grazing method is the one which requires the least inputs among the three methods, as more inputs are needed for swath and bale grazing methods to swath and harvest the forage. Compared to swath grazing, bale grazing also requires more inputs due to bale handling, during both harvest and feeding. Of the three methods, the most economical is swath grazing due to its high productivity level, followed by stockpiled grazing due to its very low input requirement.

In summary, bale grazing and stockpiled grazing have complementary benefits in Atlantic Canada. Bale grazing is mostly likely to provide feed with good nutritive value to the animals. Stockpiled grazing's main benefit is its lower cost during mid-autumn to early winter. The combination of these two extended grazing approaches appears to be a good way to extend the grazing season in Atlantic Canada. For this study, as shown in the following schema (Figure 1), extending the grazing season with stockpiled and baled forages is considered the alternate beef feeding plan in Atlantic Canada. This study will compare this alternate feeding plan to the conventional feeding plan in the study area and will determine the most economically beneficial plan for beef farmers in Atlantic Canada.

Table 1: Benefits of extended grazing season methods in Atlantic Canada

Stockpiled grazing Benefits			Swath grazing Benefits			Bale Grazing Benefits		
Inputs	Productivity	Nutritive value	Inputs	Productivity	Nutritive value	Inputs	Productivity	Nutritive value
+++	++	++	++	+++	++	+	++	+++

+ = least benefits; ++ = mean benefits; +++ = most benefits

Figure 1: Schema for extending the grazing season for beef production in Atlantic Canada

3. Methodology

The research methodology is based on the partial budgeting approach. Partial budgeting is an economic analysis approach to farm management which aims to estimate the change that will occur in farm profit or loss from some change in the farm plan by considering only those items of income and expense that change (Boehlje and Eidman, 1984). A partial budgeting approach does not calculate the total income and total expense for each of two plans, but considers only the changes that can create profit or loss for farmers. Partial budgeting is particularly useful in analysing relatively small changes in the farming system, such as changes in the feeding plan, the purchase of a piece of equipment to replace hiring a custom operator, participation in a government program, or a change in production planning (Boehlje and Eidman, 1984).

This study focuses on production costs only, so the analysis will be a 'partial budgeting of production costs'. The analysis will consist of estimating the change that will occur in farm profit by considering only those expense items that change. It is assumed that incomes are equal for the two feeding plans. The two feeding plans refer to a plan based on extending the grazing season (Figure 1) and a plan based on the common feeding approach followed by Atlantic beef farmers. The idea is to characterise, through a case study, the use of extending the grazing season in Atlantic beef production by comparing it to the common beef feeding approach in the study area. Financial data used were obtained from estimates of farm production costs in Atlantic Canada (Jones, 2011; 2013; PEI Cattle Producers, 2013) and from studies carried out in western Canada (Saskatchewan Forage Council, 2011; Manitoba Agriculture Food and Rural Development, 2015) when data for Atlantic Canada was not available.

In addition to the partial budgeting of farm production costs, the animals' performance is also analysed under extended grazing season practices in Atlantic Canada. The data used to calculate animal performance comes from the Nappan Research Farm (NRF), one of Agriculture and Agri-Food Canada's research facilities specialising in beef production research in the Atlantic region. Because extending the grazing season is not yet well developed in the Atlantic region, the idea is to verify that this feeding approach does not compromise animals' performance. This calculation will also contribute to verifying the validity of the assumption that the two feeding plans should result in the same incomes. Indeed, the use of extending the grazing season in Western Canada has proven successful in terms of output compared to conventional practices (Kelln *et al.,* 2011; Baron *et al.,* 2014; McCartney *et al.,* 2004).

4. Results

Partial Budgeting of Beef Farm Production Costs in Atlantic Canada

In order to determine the value of reduced and/or additional expenses, an Excel spreadsheet was used for an annual partial modelling of beef farm production costs (Table 2). This partial modelling considers the two feeding plans discussed above. The conventional feeding approach represents the base plan; the extended grazing season feeding plan represents the alternate plan.

The modelling approach is based on a farm with 40 cow/calf pairs and 40.5 ha (100 acres) of farmland, including 24.3 ha for pasture (grazing) and 16.2 ha for forage hay production. These values correspond to the mean values in the study area (Jones, 2013). The 'parameters per cow/calf' are expressed per year except yardage cost which is expressed per day. The modelling strategy considers four components for each feeding plan: herd characteristics; feeding periods; production costs; and other costs. The effective cost of different items for each feeding period is estimated from published data for the region, and published data for western Canada where data for Atlantic Canada is unavailable.

The herd characteristics component includes stocking rate, carrying capacity, number of cow/calf pairs, available hectares (ha) for pasture and available hectares for hay production. Stocking rate is defined as the number of animal units per 0.405 ha over a given period of time, while the carrying capacity is the maximum long-term stocking rate possible without detrimental effects on the land resource (Mark and Matthew, 2007). For this study the stocking rate is represented as the number of ha utilized by one cow/calf pair to facilitate calculations, as most cost of production parameters are expressed in dollars per unit of area utilized. The stocking rate corresponds to 0.607 ha of pasture per cow/calf pair and 0.405 ha of produced hay per cow/calf pair when they are not grazing. The carrying capacity is assumed to be the same as the stocking rate in the calculations.

The feeding periods are subdivided according to each feeding plan. For the extended grazing season feeding plan, the feeding year is subdivided into three periods: 165 days of extensive stockpiled grazing from mid-May to the end of October; 75 days of winter feeding on intensive stockpiled grazing from November to mid-January; and 125 days of winter feeding on bale grazing from mid-January to mid-May (Figure 1). This subdivision of feeding periods takes into consideration Atlantic weather conditions and the possibility to capitalise on extended grazing season approaches for winter feeding. For the conventional feeding plan, the feeding year is subdivided into two periods: 165 days extensive stockpiled grazing from mid-May to the end of October; and 200 days of barn feeding with baled hay from November to mid-May. As the summer period has the same characteristics for the two feeding plans, it has not been considered in the analysis as it does not bring any change in the comparison of costs for the two plans.

The production costs component refers to feed, yardage and straw bedding costs associated with the different feeding periods for each feeding plan. In general, farm production costs can be classified as direct and indirect

Table 2: Annual partial modeling of annual beef farm production costs for two feeding plans in Atlantic Canada

Components			Parameter per cow/calf	Conventional feeding plan	Extended grazing season feeding plan
Herd Characteristics	Stocking rate			0.607ha/pair	0.607 ha/pair
	Carrying capacity			0.607ha/pair	0.607 ha/pair
	Number of cow/calf pairs			40	40
	Surface for pasture		0.607 ha	24.3 ha	24.3 ha
	Surface for production of hay or baled hay forage		0.405 ha	16.2 ha	16.2 ha
Feeding Periods	Summer pasture days			165	165
	Winter pasture days on stockpiled grazing			0	75
	Winter pasture days on bale grazing			0	125
	Total of pasture days			165	365
	Number of days in barn			200	0
	Total feeding days		365	365	365
Production Costs	**Stockpiled Grazing**	Pasture cost	$120.00		$986.30
		Salt and Mineral	$25.00		$205.48
		Yardage cost	$0.36		$1,080.00
	Bale Grazing	Bale hay cost	$282.00		$3,863.01
		Salt and Mineral	$25.00		$342.47
		Yardage cost	$0.40		$2,000.00
	Summer Grazing	As the summer period has the same characteristics for the two feeding plans, it has not been considered in the analysis.			
	Non-Grazing Season	Hay cost	$282.00	$6,180.82	
		Salt and Mineral	$20.00	$438.36	
		Concentrate feed	$0.00	$0.00	
		Yardage cost	$0.90	$7,200.00	
		Straw bedding cost	$55.16	$2,206.40	
Subtotal (1) = Reduced Expenses = (a) - (b) = $7,548.32				**$16,025.58 (a)**	**$8,477.26 (b)**
Other Costs	Wind Break cost		$1.5	$0.00	$60.00
	Training on management skills cost			$0.00	$40.00
	Pasture watering system		$2.91	$0.00	$116.40
Subtotal (2): Additional Expenses = (d) - (c) = $216.40				**$0.00 (c)**	**$216.40 (d)**
Total				**$16,025.58**	**$8,693.66**

costs (Saskatchewan Forage Council, 2011). Direct costs include feed, bedding, minerals and supplements and veterinary expenses. Indirect costs refer to yardage costs, including manure removal cost. According to Saskatchewan Forage Council (2011), yardage cost is '*an expression of indirect costs including ownership (depreciation, housing, insurance and interest costs) and operating costs of facilities, repair and maintenance of machinery and equipment, fuel, labour, management, utilities, property tax and general and administrative costs. These costs are often charged as head days fed or grazed*'. For this study, veterinary cost is not considered as it is assumed equal for the two feeding plans. Indeed, if extending the grazing season reduces veterinary intervention it also increases the use of deworming as grazing animals can have increased gastrointestinal parasites. The feed costs, provided by Jones (2011; 2013), are costs for pasture forage, baled hay forage, salt and minerals. The cost of improved pasture forage was estimated at $80 per 0.405 ha per year (Jones, 2013). Therefore, by considering 0.607 ha per cow/calf on pasture and a farm size of 40 cow/calf pairs, the pasture cost is $986.30 for the stockpiled grazing period. The cost of baled hay per cow/calf pair per year was estimated at $282 (Jones, 2011), so the total baled hay cost is $3,863.01 for the bale grazing period and $6,180.82 for the non-grazing period. From Jones (2013), the cost for salt and mineral was estimated at $25 per cow/calf pair per year, so $205.48 for the stockpiled grazing period, $342.47 for the bale grazing period and $438.36 for the non-grazing period. Yardage cost for different feeding periods is estimated from a study carried out in western Canada (Saskatchewan Forage Council, 2011). The estimated values per cow/calf per day are $0.36 for stockpiled grazing, $0.40 for bale grazing and $0.90 for the non-grazing season. This leads to a respective yardage cost of $1,080.00 for the stockpiled grazing period, $2,000.00 for the bale grazing period and $7200 for the non-grazing period. The straw bedding cost is the amount spent to purchase bedding used to feed animals in the barn during winter. This cost, estimated at $55.16 per cow/calf pair per year, was obtained from a report on Prince Edward Island (PEI) cost of production (PEI Cattle Producers, 2013). For 40 cow/calf pairs, straw bedding cost corresponds to $2,206.40 per year. Straw bedding is no longer required under the extended grazing season feeding plan given the fact that animals are raised completely on pasture, so this is an expense item avoided in the alternate feeding plan.

The last component refers to additional indirect costs associated with the alternate plan. This includes the costs for windbreak, pasture watering system and training on management skills. Apart from the cost for training on management skills, the two other costs were estimated from a study carried out in western Canada (Manitoba Agriculture Food and Rural Development, 2015). For the windbreak, the data shows that it could cost up to $2.91 per cow per year. However, given the physical characteristics of the Atlantic region with a lot of trees that can potentially play the role of windbreak, farmers should not have to spend much money on a windbreak. The value of a windbreak was estimated at $1.50 per cow/calf per year, which equals to $60 for 40 cow/calf pairs per year. The watering system cost was estimated from western Canada data at $2.91 per cow per year, a total amount of $116.40 for 40 cow/calf pairs per year. The cost for training on management skills was estimated at $40 as a reasonable cost per farmer per year to develop skills on grazing management and strategies to extend the grazing season. We assume this training hosted by the local beef farmers' association using the participation fees of each member.

This partial modelling of beef farm production costs shows two important outputs: subtotal (1) and subtotal (2). Subtotal (1) refers to expenses for the conventional feeding plan that will be avoided by extending the grazing season. Subtotal (2) refers to additional expenses from the extended grazing season feeding plan that are not required with the conventional feeding plan. These results are summarised in Table 3.

Table 3: Partial budgeting of beef farm production costs in Atlantic Canada

1. Reduced Expenses = Subtotal (1) = $7 548.32
2. Additional Expenses = Subtotal (2) = $216.40
3. Difference (1-2) = $7,331.92
This indicates that the net financial benefit of the alternate plan exceeds the net financial benefit of the base plan.

Beef Performance Under an Extended Grazing Season Scenario

The performance of beef cattle under extended grazing season conditions were analysed through calculation of their average body weight (BW) and body condition scores (BCS) while on bale grazing at NRF. The available data obtained from NRF were animals' BW and BCS at the time they began the bale grazing period and again when the bale grazing period ended. These data were used to calculate the average daily weight gain and the average rate of change in body condition scores. Animals were bale grazed during three successive winter periods: the first period with 68 beef cattle from December 11, 2013 to February 24, 2014; the second period with 61 beef cattle from December 16, 2014 to March 09, 2015; and the third period with 59 beef cattle from December 29, 2015 to March 08, 2016. For all three grazing periods, animals were introduced on bale grazing while they were in the middle of pregnancy. The scale used for BCS at NRF is 1-9 points and the calving period is during the spring, usually in April or early May. The results are summarised in Table 4.

5. Discussion

This section discusses the results of the economic analysis of extending the grazing season in Atlantic beef production. The results show that extending the grazing can contribute to reducing farm production costs, and demonstrate that beef cattle are able to maintain good performance under an extended grazing season system in Atlantic Canada. These results are discussed below.

Extending the Grazing Season Contributes to Reducing Beef Production Costs

Comparing the total annual partial budget cost of $16,025 for the base plan and $8,693 for the alternate plan (Table 2), there is a reduction of 54% of the annual partial budget cost allowed by the alternate plan. Indeed, the alternate plan can contribute to avoiding an expense of $7,331.92 per farm per year through eliminating and/or reducing the overwintering costs for feed (16%), yardage (55%) and straw bedding (29%) (Figure 2).

With the extended grazing season feeding plan, animals are raised completely on pasture, which means that a farmer will no longer need to spend $2,206.40 per year for straw bedding. Keeping animals on pasture also offers the opportunity for Atlantic beef farmers to save

Table 4: Animal Body Weight (BW) gain and BCS change under winter bale grazing in Atlantic Canada

Periods		Animal head	Average weight	Average BCS
1st Period (65 days)	Put into bale grazing	68	1574.5	7.2
	Taken out of bale grazing	68	1582.5	5.9
	BW gain (lbs) and BCS change		**+ 0.1**	**-1.3**
2nd Period (85 days)	Put into bale grazing	61	1600.2	6.4
	Taken out of bale grazing	61	1645.9	6.3
	BW gain (lbs) and BCS change		**+ 0.5**	**- 0.1**
3rd Period (70 days)	Put into bale grazing	59	1536.2	6.5
	Taken out of bale grazing	59	1570.7	6.7
	BW gain (lbs) and BCS change		**+0.5**	**+0.2**

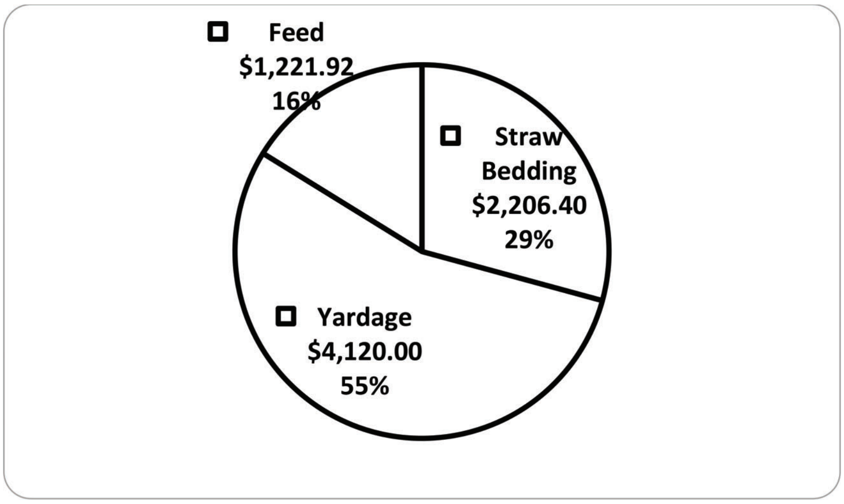

Figure 2: Expenses avoided per beef farm per year by extending the grazing season

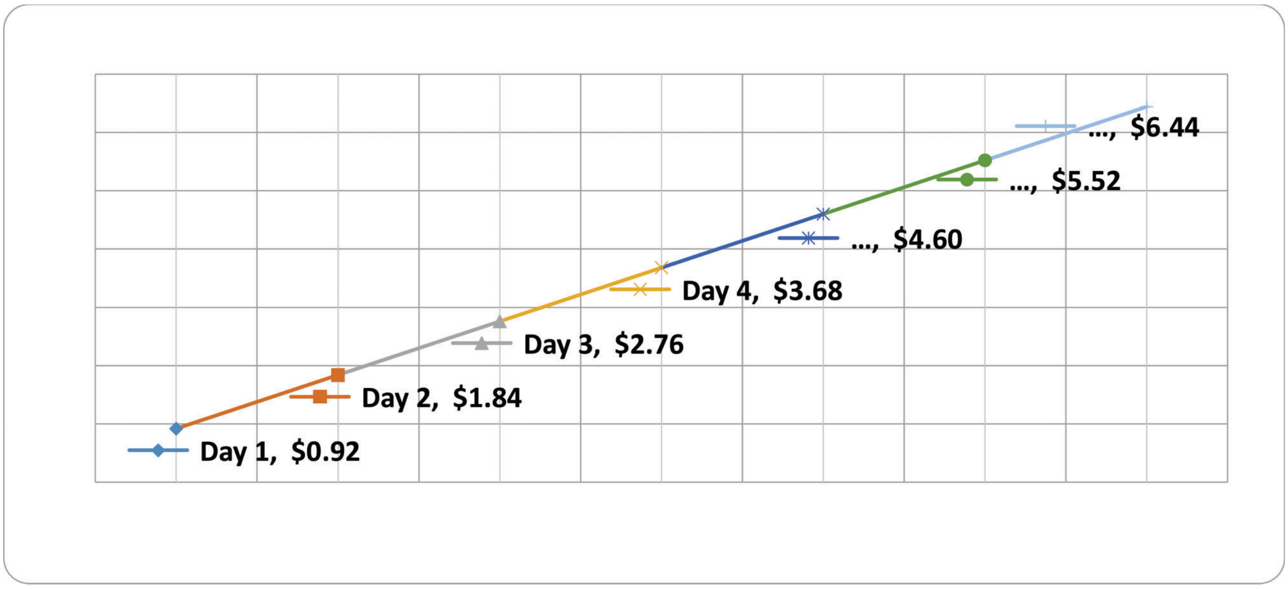

Figure 3: Expenses avoided per cow/calf days of winter grazing

additional costs including feed, building depreciation and repairs, machinery, fuel, labour and manure removal. The model shows that feed and yardage costs can be reduced by $1,221.92 and $4,120 respectively. This means a total cost of $7548.32 avoided, with a net cost saved of $7,331.92 per year, by taking into account the additional costs of $216.40 for windbreak, watering system and management training.

The period considered for the study is the overwintering period from November to mid-May (200 days), as the summer period is not taken into account. By considering the 200 days of overwintering period, the model indicates that extending the grazing season can lead to a saving of $0.92 per cow/calf per day. Thus as the number of cattle days on pasture increases, the greater the reduction in production costs (Figure 3).

Extending the grazing season is thus the most economically efficient feeding plan for Atlantic beef farmers. This result corroborates many results from western Canada showing the contribution of extending the grazing season to reducing winter production costs in beef production (Kaliel, 2004; Baron *et al.,* 2014; McCartney *et al.,* 2004). Atlantic beef farmers may thus improve the financial viability of their farm through the adoption of the extended grazing season feeding plan in their production system.

Extending the Grazing Season Does not Compromise Animals' Performance

Animals began bale grazing when they were in the middle of pregnancy. This makes it difficult to obtain a reliable body weight gain due to the interaction of the weight of maternal tissues with specific physiological stages such as pregnancy (Gionbelli *et al.,* 2015). In this situation, the body condition score, closely related to beef reproductive efficiency, is a more reliable indicator of the nutritional status of beef cattle (Rasby, Stalker and Funston, 2007).

The body condition score presents two advantages to help estimate the probability of re-breeding as well as calving condition. A high BCS may result in calving issues, mainly due to increased dystocia; while a low BCS may compromise beef re-breeding capacity, mainly by increasing the post-partum interval. These situations could result in reduced income for the beef farmer. According to Parsons (2009), it is recommended that mature cows calve with a BCS of at least 5 and not more than 7. At NRF, it is generally expected that cattle will calve with a BCS between 5.5 and 6.5. The BCS at calving time of cows that bale grazed fall between 5.9 and 6.7 (Table 4) and thus are appropriate to allow for good reproductive performance. These results, along with the observations of beef specialists who conducted the study at NRF, reflect that animals at NRF have been able to maintain good performance on winter bale grazing.

Given the results of three bale grazing trials at NRF it is possible to say that, in the Atlantic region, beef cattle are able to maintain good performance in an extended grazing season feeding system. This result corroborates the results from western Canada showing that animals' performance on extended grazing season approaches were comparable to conventional feeding practices (Kelln *et al.,* 2011; Baron *et al.,* 2014). An extended grazing season feeding plan can thus procure an output comparable to the conventional feeding plan in Atlantic beef production.

6. Conclusions and Implications

The aim of the study was to determine, in comparison to the conventional feeding approach, the advantages and expected value of extending the grazing season in Atlantic beef production using stockpiled and baled forage. The purpose was to identify the most efficient feeding plan for Atlantic beef farmers using the partial budgeting approach.

The results show that, compared to the conventional feeding plan in Atlantic Canada, an extended grazing season approach is a more efficient feeding plan for Atlantic beef farmers. An extended grazing season feeding plan can reduce by 54% the total annual production cost for feed, yardage and straw bedding, compared to the conventional feeding plan. Indeed, extending the grazing season can contribute to avoiding expenses of $7,331.92 per farm per year through eliminating and/or reducing overwintering costs for feed (16% reduction), yardage (55% reduction) and straw bedding (29% reduction). A detailed analysis shows a saving of $0.92 in overwintering production costs per cow/calf per day. Therefore, as the number of cattle days on pasture increases, the greater the reduction in production costs will be. Furthermore, the results of animals' performance on winter bale grazing in Atlantic Canada show that the animals' weight and body condition score are at desirable levels.

The extended grazing season feeding plan could be an alternative solution to enhance beef farm financial viability in Atlantic Canada. In addition, it can also contribute to the sustainable development of beef farms through services provided by grassland systems such as carbon sequestration, recreation functions and environmental protection. These results reflect the need for forage and beef cattle production specialists to support and promote the adoption of extending the grazing season techniques for beef production in Atlantic Canada. This support could involve awareness, training on grazing management skills, workshops and participatory research.

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Acknowledgement

We would like to acknowledge Agriculture and Agri-Food Canada for funding this study. We also thank the following persons for their contribution to this study: Jonathan Wort (Perennia, Truro), Darren Bruhjell (AAFC, Lacombe), Cedric Macleod (MacLeod Agronomics, New Brunswick) and Emmanuel Yiridoe (Dalhousie Agriculture Campus, Truro). We would also like to thank the Maritime Beef Council for their support.

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DOI: 10.5836/ijam/2017-06-40

Just Jovial John – an appreciation of John Alliston

JOHN WIBBERLEY

John Alliston was a real star; always fair-minded and full of good humour. I first met John over forty years ago. What you saw in John was what you got – an open smile, great sense of fun, good listening and genuine friendliness. He wore his scholarship lightly but sustained a wide-ranging applied research and teaching involvement. He first graduated in Agriculture at the University of Aberdeen. I guess John won his management credentials as Farm Manager & Head of Farms at the Institute of Grassland & Animal Production, which was then near Reading, having previously lectured at Cirencester after gaining his PhD. When I gave 12-months' notice to leave The Royal Agricultural College Cirencester in 1988, I was delighted when John succeeded me in July 1989 as Head of Agriculture. He was subsequently appointed Professor of Agriculture there in 2000, and stayed until his retirement in 2011, though continuing with part-time involvement until his death.

John's focal research interests were in livestock production from grass and forage crops. His Nuffield Scholarship in 1986-7 featured studies of white clover in New Zealand and Australia. He subsequently chaired the Maize Development Association in the UK, gained a Waitangi Scholarship (Fellowship) to NZ and developed his work on Agricultural Leadership further through a Nuffield Jubilee Scholarship. John led many Advanced Agricultural Business Management short courses of the London-based Worshipful Company of Farmers & Institute of Agricultural Management - for some 18 candidates per course. He led many Management Development Scheme courses for the John Edgar Trust. He gained the *Farmers Weekly* Lifetime Achievement Award in 2016. John's balanced interests across the spectrum of practical agriculture were reflected in his awards of Fellowships – of the Institute of Agricultural Management (FIAgrM); of the Institution of Agricultural Engineers (FIAgrE), and Fellowship of the Royal Agricultural Societies (FRAgS) which he attained in 1992 for outstanding work, having been awarded Associateship in 1988.

John Alliston was passionate to see people developed and skilled in agricultural management, and served IFMA with distinction as our President from 2009-2013. He was chosen in 2014 by Lord Plumb (a past President of the NFU, and of the European Parliament from 1987-1990) as the first Chairman of the Henry Plumb Foundation for mentoring and enabling young entrepreneurs, a post he discharged with characteristic enthusiasm while engendering good teamwork.

In all of his work and considerable achievements, John's ever cheerful face was never far from a slightly mischievous grin! He never took himself too seriously. For instance, no IFMA Congress was complete without John sneaking off for a round of golf with JJ Harty! Ireland's recent defeat of England was tempered by John's delight that England were overall winners of the Six Nations – a fact John would have enjoyed reciting within earshot of Murrayfield at IFMA21 in Scotland! He consistently supported Southampton's football team *The Saints,* and savoured their victories.

John was a real 'people person', an encourager with a ready wit – but always kindly. He was not overfond of undue bureaucracy nor of excessive technology; he once told me he thought that 'www' meant the wonderful world of Wibberley! All of us who knew John miss him and salute the enormous contributions he made, not least to our IFMA (International Farm Management Association). Our thoughts and prayers are very much with his dear wife Petey, their sons Michael and James, and their wider family.

REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-41

A comparison of whole farm budgets versus farm accounts and suggestions for future planning of farm expansion and economic management

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ABSTRACT

For the farming family, planners, banks and other lending institutions it is crucial to know how reliable whole- farm budgets are, and what the pitfalls are. We explore how well whole- farm budgets match with the accounts in the first years after investment in a new cowshed. We explain what causes the discrepancies and suggest how budgeting can be improved. We follow a panel of 36 dairy farms in Norway over a period of three to five years. All farms have undertaken large investments in cowsheds. We merge the interview data with a database on herd data, whole- farm budgets and accounts data. There are significant discrepancies between whole- farm budgets and accounts, particularly when it comes to fixed costs, investments and debt. Milk production well beyond budgets, deviation from estimated building cost, unplanned investments and poor budgeting practices are some of the reasons for the discrepancies. Farmers struggle with transition problems when the new cowshed is put into use. Recommendations to improve the process of farm expansion and managing the economy after the expansion are provided.

KEYWORDS: farm expansion; dairy farming; transition problems; beyond budgeting; fixed costs

1. Introduction

To get funding for new cowsheds farmers usually need to submit a whole- farm budget. Such an investment has important financial impacts, and farmers use whole farm budgets to become confident that the investment is prudent. Also for planners and lending institutions it is crucial to know how reliable the budgets are, what the pitfalls are, and how they function as a management tool. Few studies have explored the reliability of whole-farm budgets in retrospect. This study addresses how well whole- farm budgets match with farm accounts, proposes suggestions to improve the whole budgeting and planning process, and discusses new tools to manage farm economics after investment in a new cowshed. The remainder of the paper is organized as follows. After reviewing theory and literature we present the material and methods used. Then follow results, discussion and conclusion.

Literature review and theory

Budgeting is the process by which companies project revenues, expenses, profits, and cash flows for the upcoming accounting periods. Thus, the budget shows the financial impacts of the plans for the period and aims to help the company to manage and dispose of financial resources in the best possible way (Anthony and Govindarajan, 2007). The budget traditionally has been, and still is, the dominant tool for management accounting and control. Budgeting is used as a *planning tool*, a plan for the total activities of the company, to give the manager a complete overview and make sure that the company is moving in the right direction (Bergstrand, 2009). Budgets also function as a basis for *performance evaluation.* By investigating the reasons why the variations occur during the budget period, actions can be taken (Anthony and Govindarajan, 2007). Finally, budgets can create motivation among managers and employees by setting clear and defined targets (Bergstrand, 2009).

Despite the advantages offered by budgets as a tool of management, both practitioners and scholars have expressed their concern about the possible disadvantages of traditional budgeting. First, budgets are criticized for being time consuming and costly to make, with a high level of details representing uncertain expectations in an increasingly dynamic environment (Otley, 2003; Bogsnes, 2009). Second, the budgeting process takes too long compared to the movements in the environment, and budgets become

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rapidly out- dated during the course of a budget year (Otley, 2003; Bergstrand, 2009). Third, the fixed budget does not allow for the identification of new risks and opportunities due to its fixed and unchanging representation of the business plan at the time the budget is set (DeLeon, Rafferty and Herschel, 2012). Thus budgets prevent managers from responding quickly to changes and are often a barrier to change (Bergstrand, 2009). Fourth, budgets are decoupled from strategy and focus on cost reduction, rather than value creation and strategically important issues (Hope and Fraser, 2003; Bogsnes, 2009). Thus, inspired by Wallander (1999), Hope and Fraser (2003) introduced a new approach to management control; Beyond Budgeting (BB). In short, BB is about replacing command-and-control with a management model that is more empowered and adaptive (Hope and Fraser, 2003; Bogsnes, 2009). Within the BB concept The Balanced Scorecard (Kaplan and Norton, 1992) (BSC) and rolling forecasts (Hope and Fraser, 2003) (RF) are two of the most known.

In a review of the performance effects of BSC use, Madsen and Stenheim (2015) did not find any effect of BSC use on financial performance. A similar result was found by Bjørnenak (2013). Therefore, we do not focus on BSC in this paper, but rather on RF. Bergstrand (2009) defines RF as projections of a small number of key variables that are updated on a rolling basis. As opposed to budgets, RF aims to represent an unbiased, expected outcome; they typically have less line items, shorter time horizon, and more frequent updates (Goyagina and Valuckas, 2012). The RF approach differs from the traditional fixed budget in that it eliminates the constraints of a set forecast period with a defined and unchanging end point (De Leon *et al.*, 2012). The forecasts are frequently updated, typically each quarter or month, and the updates consist of re-forecasting for at least the upcoming year (Libby and Lindsay, 2003a). As one month or quarter ends, it is simply dropped from the forecast and a new month or quarter is added (De Leon *et al.*, 2012).

In a literature review of RF Golyagina and Valuckas (2012) found few academic articles. However, a few promising results exist. Clarke (2007) claims that companies are willing to adopt RF since they are more accurate than budgets, assist in achieving company objectives, and supply useful information for risk-management. Similarly, Ton- Nu (2014) found that implementation of RF mitigated the dysfunctional and gaming behaviour caused by the budgeting process. Managers also had a positive attitude towards RF. However, to be of use RF must be simple and focus on the critical key performance indicators (Bjørnenak, 2014). Otherwise, the preparation process can become costly, complex and time consuming, and the potential positive effect may vanish (Bjørnenak, 2014; Lorain, 2010). Finally it is noteworthy that Bjørnenak (2013) found a positive effect of benchmarking on profitability.

Previous studies in agriculture

Nergaard (1988) found that farms in need of governmental refinancing did not achive their budgeted results for crops, yield and operating profits. The farms also exceeded their upgrading expenditures more than other farms. In a one- year study of 19 Norwegian dairy farms (Haukås and Solberg, 2010), the milk quota, dairy income, variable and fixed costs were significantly higher than budgeted on farms that had invested. The farm net income was on target. The high fixed costs were due to additional investments after the main investment, and general underestimation. Similar results were found in Haukås (2012). The farm net result exceeded budgets, but varied a lot between farms. Ruud- Wethal *et al.* (2012) studied farm accounts the year before and after investment, and found lower gross margins, lower farm net results, and higher fixed costs than budgeted. Davey and Nettle (1997) suggest farm expansion should be guided by more relevant management accounting and careful budgeting to succeed in terms of profit and personal satisfaction. As pointed out by Davidsson *et al.* (2008), MacPherson (2005) and Alvarez and Arias (2004) growth faces managers with challenges, and not all farmers master these challenges equally well. Thus, Hansen and Jervell (2014) showed that new technologies and farming systems can be introduced on similar farms with very different results, dependent among other factors on the farmer's change capacity. Firms that grow successfully do so by first securing profitability, and then grow (Davidsson *et al.*, 2005). In the short run adjustment costs from affecting ongoing production negatively (Nilsen *et al.*, 2007) and managerial challenges are likely to reduce the short term gains from augmented volume. The key point is that adaptation to a larger herd, new routines and new cowshed takes some time (Sipiläinen, 2008). Finally, Tanewski *et al.* (2000) claim that the main reason why budgets and accounts differ, is that business planning in agriculture is mainly due to lender requirements.

Few studies have analyzed a panel of dairy farms covering both the years before and after farm expansion, and conducted longitudinal statistical analysis to explore the causes of discrepancies between accounts and budgets. Further, few studies have combined financial data with herd recordings and interviews with farmers to gain a deeper understanding of why these discrepancies occur. To help both planners and farmers counteract the problems facing farmers through farm expansion, such detailed knowledge is crucial.

Three research hypotheses are posed in light of our theory and literature review: (1) discrepancies between whole-farm budgets and accounts occur early in the budget period due to underestimated fixed costs and additional investments; (2) transition problems can partly explain the discrepancies between whole-farm budgets and accounts; (3) whole- farm budgets are to a small extent used as a management tool after investment, and new tools are required.

2. Materials And Methods

Respondents and sampling

This study was conducted in Rogaland, one of the main milk producing counties in Norway. We divided the county in four regions. In each region we selected a number of respondents randomly, according to the regions' share of the total milk production. One requirement was that the farms should have three full years of operation after the farm expansion. After we had collected the herd data from 30 farms we realized that only 24 of the 30 farms had both complete herd recordings and budgets. To get sufficient data we therefore added six more farms which had both budget and herd data, according to the procedure described above. We analyse two datasets, one with herd data only, and one with accounts and budget data. Both datasets contain 30 farms, and 24 of the 30 farms are included in both datasets. The remaining six are included in one of the sets only. In total, we interviewed 36 farmers. In this study our main interest is the accounts and budget dataset, and approximately 80 percent of our results relates to this dataset. Therefore, we use interview data from the 30 farmers in the accounts and budget set only. The two datasets are unbalanced (Table 1) because not all farms had more than three fiscal years. Only one farmer refused to participate in the study, and no farmers withdrew from the study. Nothing suggests that the probability of missing a farm or a single variable on a farm depends on the potentially observed values. Thus it is fair to claim that both farms and variables are missing at random.

Women are the main practitioners on three farms, both genders are involved in farming on nine farms, and men are the main practitioners on 24 farms. The mean age of the farmers is 47 years. Two thirds of the farmers are educated agronomists, and two thirds also have high school education. In total 19 farms are joint operations, and typically one active farmer rents milk quota, farmland and cows from the other participants, who are passive. In year one 21 farms had a milking robot.

In year three after investment the mean quota was 388,792 litres of milk, ranging from 169,850 to 795,100 litres. One year before investment the average number of cows was 31.1, and by year three it had increased to 48.9, or approximately twice the average herd size in Norway in 2014 (Tine, 2014). On average the farms increased their milk quotas by 79%. Eighteen of the farmers also have sheep, eight have pigs and four have poultry.

The herd dataset

The recordings are made regularly by farmers and veterinarians every second month, and contain data on feeding, animal health, herd fertility, milk quality etc. They cover the period up to three years ahead of, and five years after investment (Table 1). We number the years relative to year zero, the year when the new cowshed was put into use.

The accounts and budget dataset

The accounts were kept by local accountant offices. Fifty- eight percent of the budgets were made by accountants, and the remaining by different actors. The budgets were prepared using different tools. Many budgets contained very little information about the underlying assumptions, e.g. the number of cows. Thus, comparing accounts and budgets was a daunting task, and some of the reported differences may therefore be due to methodological issues. Joint farming operations were particularly challenging, and we collected account data from both each partner and the joint operation as a whole. While other farm production may have influenced the figures, milk is the main output on most of the farms.

Table 1: Number of farms in the herd dataset and the accounts- and budget dataset in the years before, during and after the investment

	Year relative to investment year zero								
Dataset	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
Herd dataset	1	29	29	30	30	30	28	20	5
Accounts- and budget dataset					30	30	30	20	4

Dependent variables

Hansen *et al.* (2005) showed that in order to fill the milk quota it is important to be economically efficient. Milk quota filling is the percentage of the quota the farmer manages to deliver to the dairy. Short term debt is the difference between total debt and long term debt. The remaining dependent variables are calculated by dividing the accounts values by the budget values. Summary statistics are given in Table 2.

Other fixed costs is a denominator for different costs including rent of land and milk quota, administration, insurance, accounting, energy, maintenance of fields and soil etc. Machinery costs include maintenance, fuel, leasing, contracting etc. Farm net result includes all farm income minus variable and fixed costs. We use the result before depreciation to make it easier to compare farms. In addition, we use the percentage culled cows of all cows in year zero in Tukey's HSD test. The mean percentage culled cows was 50.7%, with a standard deviation of 15.5%.

Independent variables

The variable named "Milk beyond average" means that the farmer delivers more milk than average compared to the budget in the last fiscal year. Thirty-seven percent of the farmers told us that their debt level worried them, or that they think about it; we refer to them as risk adverse. The rest do not bother much about their debt. Further we divide the farmers own effort in the building process as either straightforward or too extensive, based on their own judgements.

Method

We chose a mix of quantitative and qualitative methods. To check the deviations between accounts and budgets we used paired t- tests for variables that are approximately normally distributed. All our dependent variables are continuous. To explore the reasons for the discrepancies we applied one way analysis of variance, Tukey's HSD (honest significance difference) test, linear mixed models (LMM) and generalized linear mixed models (GLMM) (Fitzmaurice *et al.*, 2004). In building the statistical models we first checked the distribution of the dependent variables by plotting empirical quantiles of the variables against theoretical quantiles of a comparison distribution. Density plots and quantile plots revealed that other fixed costs fit well with a gamma distribution, while machinery costs fit better with an inverse Gaussian distribution. All other dependent variables are approximately normally distributed. In this study the number of measurement occasions is relatively small, and all farm results are measured at the same set of occasions. It is then reasonable to allow the covariance matrix to be unconstrained (Fitzmaurice *et al.*, 2004). We started with as many explanatory variables and interaction effects as possible. Then we applied REML (Restricted Maximum Likelihood) to determine an optimum structure of the random effects. Next we determined an optimum

Table 2: Descriptive data for the dependent variables in the regression models, account values divided by budget values

	Mean	Std. dev.	Min	Max
Quota filling	0.957	0.100	0.430	1.170
Other fixed costs	3.072	2.506	0.463	13.017
Machinery costs	2.433	1.669	0.204	8.823
Farm net result before depreciation	0.853	0.435	-0.404	2.103
Share of short term debt of total debt	0.254	1.343	-0.178	14.430
Total farm debt	1.217	0.421	-0.040	2.775

structure for the fixed effects by the use of ML (Maximum Likelihood). Finally, we estimated the chosen model by REML. To determine which variables to include in the final model we used Aikaikes Information Criteria (AIC) and Bayes Information Criteria (BIC) for non- nested models. For nested models we also applied hypothesis testing on parameters using Wald- test, F- test and Likelihood ratio test. To validate the models we plotted the deviance residuals, the Pearson's residuals, and the residuals against the fitted values. A major finding is that inclusion of a random intercept for farmer improves the explanatory power in all our models. For LMM we applied the lme- procedure in R, and for GLMM we applied the glmmPQL (Penalized Quasi Likelihood) procedure. PQL estimates are less precise than maximum likelihood estimates. However, the software for this procedure is perhaps the most robust one. A test of the GLMM- models applying the glmer- procedure in the lme4 package did not yield significantly different results as compared to the glmmPQL- procedure. The glmer- procedure applies the Gauss Hermite approximation to the log likelihood. This approximation is closely linked to the Gaussian distribution and demands that data can be grouped in clusters. As link function for the GLMM-models we used log link, as this is usually the preferred one for Gamma and Inverse Gaussian distributions (de Jong and Heller, 2009).

We visited and interviewed the farmers late autumn 2014, and asked them about their experiences before, during and after the transition period. We used a largely unstructured interview to capture the respondents' thought processes, the frame of reference, and feelings about an incident or set of incidents, which had a meaning to the respondent. The farmers talked about how they run their farm and the challenges they faced in their own words, and appreciated talking about their farming in a natural setting. We promised the farmers not to quote them in such a way that they could be identified. After transcribing the interviews we used HyperResearch to code and analyse them. The coding reflected the variables used in the quantitative analysis. Next, codes were transferred to the two data sheets, the herd data, and the accounts- and budget data.

3. Results

In Table 3 we compare accounts and budgets. We do not show data for year five, as we have data for five farmers only. Further, we do not perform t- tests for variables which are strongly right- skewed, such as investment variables, hired labour costs, other fixed costs and machinery costs.

From Table 3 we can see that from year two onwards there are many significant discrepancies between the accounts and the budgets. The farther away from year zero we move, the larger the differences. On average the farmers exceed their milk production target in year three and four. This contributes to a positive deviation in total gross margin in the same period. However, the gross margin per litre milk does not deviate significantly from the budgets. Estimated yearly building costs also match well with the accounts, while other fixed costs, labour costs and machinery costs are significantly underestimated. In total, the negative deviations in fixed costs more than outweigh the positive deviations in gross margins. The result is a farm net result before depreciation significantly below budget for the whole period.

Farmers have invested more than budgeted, or in other words, the budgets have not taken necessary future investments into account. Negative values for building investments indicate that the planned investment has been postponed from one year to the next, while negative values for machinery means that the farmers have redeemed machines. The distributions, particularly for investments in farmland and milk quotas, are highly right-skewed. Thus a few farmers have invested large amounts. On the other hand, many farmers have invested more than budgeted in farm machinery. With higher fixed costs and larger investments than budgeted, it is no surprise that both long term debt and total debt is significantly higher than budgeted from year two on. Already in year two the difference is more than one million NOK, and increases to two million in year four.

In the following statistical analyses we use the accounts- and budget dataset. Other fixed costs differ significantly from the budgets, and in Table 5 we show which factors can explain the deviations.

The random intercept for farmer is 0.6454, corresponding to an intra-class correlation of 11.2%. From Table 5 we notice that milk delivery beyond budget contributes to higher other fixed costs than budgeted. For example, if the farmer produces 12% more than budgeted, other fixed costs are approximately 1.8 times the budgeted costs. However, if the farmer belongs to the group which produces beyond average, e.g. 25% more, other fixed costs become 3.4 times the budgeted amount. Thus, we see that milk delivery beyond average triggers a strong increase in other fixed costs, because it also entails milk delivery beyond budget.

Now we explain why the machinery costs also differ significantly from the budgets (Table 6).

The random intercept for farmer has a standard deviation of 0.358, corresponding to an intra-class correlation of 3.7%, which is low. The machinery costs in the accounts increase compared to budgets as farmers produce more milk than budgeted, and decrease the more farmers they discuss their farming with. As an example, consider a farmer who has milk delivery on target and four discussion partners. The machinery cost becomes 1.7 times the budgeted amount. If the farmer delivers 1.2 times the planned amount, this ratio increases to 2.1, given the same number of discussion partners. Increasing the number of discussion

Table 3: Mean differences between accounts and budgets in NOK[3] for each year and on average, except from litres of milk delivered*

	Year				
Variable	**1**	**2**	**3**	**4**	**Average**
Litres of milk delivered	-9223	14961	39 802[2]	61606[2]	29 545[2]
Gross margin per litre milk	-0.302	0.218	0.220[1]	0.301	0.119
Overall farm gross margin	-87191	187 495[2]	283342[2]	273671[2]	178 450[2]
Hired labour costs	55 562	50 302	64962	124689	81 520
Other fixed costs	185 005	214 303	248593	333607	239 554
Machinery costs	129270	155192	155482	202849	169 318
Building costs	-31455	-4868	38275	16491	10101
Farm net result before depreciation	-351 653[2]	-135 253[2]	-110393[2]	-189335	-193 214[2]
Long term debt	-24549	681 645[2]	733172[2]	1294254[2]	666 336[2]
Total debt	457456	1 332 222[2]	1306826[2]	2188773[2]	1 315 756[2]
Investments					
Farm land and milk quota	111504	66103	44175	208910	98136
	4824	4908	5527	5528	4908
	-595176	0	0	0	0
	2100000	1321293	361503	3222707	3222707
Farm buildings	389459	186427	119972	444315	297098
	74987	21531	0	36250	38200
	-726955	0	-1495643	0	-1495643
	2580898	1870227	1734262	5552405	5552405
Farm machinery	86784	192902	117869	70797	118696
	34750	117716	59603	11895	47600
	-90492	-217250	-106750	-33900	-217250
	468377	1015492	735300	557000	1015492

*For the investment variables we show the mean, the median, and minimum/ maximum values of the differences. Significant p- values from the t- tests are marked for variables which are approximately normally distributed.
[1] $p < 0.1$
[2] $p < 0.05$
[3] At the time of writing (end-November 2015), NOK1 was approximately equivalent to £0.077, $US0.12, and €0.11.

Table 5: Other fixed costs in the accounts divided by other fixed costs in the budgets, regressed on milk delivered to dairy in accounts versus budgets, and milk delivery beyond average*

Dependent variable: Other fixed costs in the accountancy versus budget				
Explanatory Variables	**Parameter estimates**	**Standard error**	**t-value**	**p-value**
Milk delivery in account vs budget	0.4127	0.1589	2.5981	0.0110
Milk delivery beyond average	0.5902	0.2552	2.3125	0.0283
Intercept	0.1239	0.2220	0.5582	0.5781

*Fixed effects estimates from fitting a generalized linear mixed model with random intercept and gamma response, link =log, n=119.

Table 6: Machinery costs in the accounts divided by budgeted costs, regressed on milk delivery in the accountancy versus budget and number of network members*

Dependent variable: Machinery costs in the accountancy versus budget				
Explanatory Variables	**Parameter estimates**	**Standard error**	**t- value**	**p-value**
Milk delivery in account vs budget	0.9076	0.1815	4.9994	<0.0001
No of discussion partners	-0.0794	0.0262	-3.0330	0.0056
Intercept	-0.0529	0.2237	-0.2363	0.8138

*Fixed effect estimates from fitting a generalized linear mixed model with random intercept and inverse Gaussian response, link=log, n=106.

partners for the last farmer to eight, reduces the ratio to 1.5, given the same milk delivery.

A male farmer in his fifties and a couple in their forties gave us a clue why the fixed costs in the accounts differ so much from the budgets:

> *"The challenge of growth is to provide enough machinery; mowers, tractors, manure wagons, yes it's about transportation, and about workload. We feel that the forage production is far more costly than we had anticipated. Machinery, contractors and so on are more expensive than we had thought of."*
>
> *"You have to make some compromises here and there. During the building period we were offered many things which are nice to have, and many have built more expensive and finer than us, but we did not want that much debt on this project."*

These statements indicate that the budgets do not take all costs due to increased volume into account, and that it pays off to be sober and stick to the plan during the building process. A couple in their forties also stressed the importance of sticking to the plan:

"I think it was a good thing to avoid changing anything after we decided on the cowshed drawings. I have seen that before during a hectic building period. You suddenly get a 'good' idea, and afterwards you realize it is was not that good after all."

Strong growth beyond budgets entails high fixed costs which can hamper profitability. In Table 7 we show which factors predict the deviations in farm net result before depreciation.

The random intercept for farmer has a standard deviation of 0.203, corresponding to an intra- class correlation of 1.25, which is remarkably low. However, a likelihood ratio test revealed that the random effect is significant ($p<0.05$) and yields a large decrease in the AIC and BIC values. For example, if the farmer manages to produce a gross margin which is 20% higher than the average as compared to budgets, and the machinery costs are on average, the farm net result ends up 29% beyond average. If the gross margin is on average as compared to budget, and the machinery costs are 20% below average, the farm net result ends up six percent higher than average as compared to budgets. This result shows that to achieve a high farm net result before depreciation it is particularly important to run the farm well, and then comes controlling machinery costs.

Short term debt is an indicator of strained liquidity, and therefore we are interested in which factors can explain the level of short term debt (Table 8).

The random intercept for farmer has a standard deviation of 0.692, corresponding to an intra-class correlation of 12.7%. Short term debt increases with investments in farm machinery and deviation from estimated building costs. For each percent deviation in building costs, short term debt increases by four percent, which is significant. If a farmer with one percent deviation in addition invests 100,000 in machinery, short term debt becomes 25.8% of total debt, which is high. Thus, it is crucial to keep both building costs and machinery investments under control to avoid liquidity problems.

In Table 9 we show which variables predict the level of total debt in accounts versus budgets.

In Table 9 the difference in building investment between accountancy and plan are divided by 1 million. The random intercept is calculated to 0.318, corresponding to an intra-class correlation of 3.0%, which is low. The deviation in total debt increases every year from year one on, in line with the findings in Table 3. Higher milk delivery than planned increases total farm debt, and the effect is stronger if it also entails building investments. Such investments beyond year zero are only occasionally included in the budgets. All other factors kept constant, risk takers have 34% higher debt than risk adverse farmers, which is significant. Thus, farmers' risk perception has a significant influence on the level of debt as compared to budgets. Taken together our findings support hypothesis one, that whole farm budgets quickly become out- dated due to underestimated fixed costs and additional investments. In addition we have also identified several other causes why budgets and accounts differ.

In the following we analyse the transition problems during farm expansion. We use the herd dataset to explore the quota filling (Table 10).

The random intercept term for farmer has a standard deviation of 2.513, which corresponds to an intra- class correlation, or the between farmer variation, of 65.7% of the total variation. This is remarkably high. There is a tendency that if farmers think their own effort in the building process was straightforward, the quota filling increases by 3.5% in each year. A farmer in his forties explained:

"It costs in terms of health, I felt totally exhausted when the building period was finished…But the real work starts afterwards you know, when you need to follow up the herd. So it's not just building. I had not done this again."

Thus if farmers feel worn out when the building period is over, it affects subsequent milk production negatively.

Table 7: Farm net result before depreciation in the accounts divided by result in the budgets, and regressed on total gross margins and machinery costs in NOK in accounts versus budgets*

Dependent variable: Farm net result before depreciation in accounts versus budget				
Explanatory Variables	**Parameter estimates**	**Standard error**	**t-value**	**p-value**
Total gross margin in account vs budget	1.5010	0.2170	6.9158	<0.0001
(Total gross margin in account vs budget)^2	-0.2036	0.0801	-2.5435	0.0128
Machinery costs in account vs budget	-0.0916	0.0248	-3.7000	0.0004
Intercept	-0.3985	0.1582	-2.5194	0.0136

*Fixed effects estimates from fitting a linear mixed model with random intercept, n=119.

Table 8: Short term debt divided by total debt, and regressed on machinery investment in NOK and deviation from estimated building cost in percent*

Dependent variable: Short term debt divided by total debt				
Explanatory Variables	**Parameter estimates**	**Standard error**	**t-value**	**p-value**
Machinery investment	$0.2 \cdot 10^{-6}$	$0.7 \cdot 10^{-7}$	3.2338	0.0018
Deviation from building cost in percent	0.0404	0.2150	1.8796	0.0710
Intercept	-4.2935	2.3132	-1.8561	0.0670

*Fixed effects estimates from fitting a linear mixed model with random intercept, n= 113.

Table 9: Total debt in accounts divided by total debt in budgets, regressed on planning year, milk delivered in accounts compared to budgets, farmers' attitude towards risk, and differences in building investments in accounts vs budgets*

Dependent variable: Total debt in accounts vs budgets				
Explanatory Variables	**Parameter estimates**	**Standard error**	**t-value**	**p-value**
Year	0.0587	0.0165	3.5475	0.0006
Milk delivery in account vs budget	0.2808	0.1110	2.5302	0.0133
Risk adverse farmer	-0.3397	0.1254	-2.7098	0.0114
Building investment	-0.1556	0.0772	-2.0169	0.0470
Milk delivery in account vs budget · Building investment	0.2034	0.0500	4.0704	0.0001
Intercept	0.9313	0.1440	6.4690	<0.0001

*Fixed effects estimates from fitting a linear mixed model with random intercept, n=116.

Table 10: Milk quota filling regressed on quota size in litres, number of cows, milk yield per cow and own effort during building new cowshed*

Dependent variable: Milk quota filling				
Explanatory Variables	**Parameter Estimates**	**Standard error**	**t- value**	**p-value**
Milk quota	-0.00041	0.00004	-10.934	<0.0001
No of cows	2.6644	0.393	6.785	<0.0001
(No of cows) ^{2}	-0.0363	0.0076	-4.7682	<0.0001
Milk yield per cow	0.0071	0.0008	8.415	<0.0001
No of cows · Milk quota · 10^{-4}	0.00001	0.000001	6.1213	<0.0001
Own effort straightforward	3.4979	2.0334	1.7202	<0.0988
Intercept	47.7401	7.6034	6.2788	<0.0001

*Fixed effect estimates from fitting a linear mixed model with random intercept, n=166.

Quota filling decreases with quota size, and increases with milk yield per cow and number of cows, but the increase is gradually offset by the negative quadratic term. This means that for large herds the net effect from increased number of cows is negative. Thus, in large herds it is more efficient to increase the milk yield. However, for a medium size farmer it is important to increase both the milk yield and the number of cows simultaneously. Take the example of a farmer who has a milk quota of 150 000 litres one year ahead of investment and increases the quota by 100%. If the farmer only manages to increase the number of cows by 60% and maintains the same milk yield, the quota filling becomes 91.2%. Similarly, if the farmer manages to increase the milk yield by 60%, but maintains the same number of cows, the quota filling is only 87.6%.

The interviews revealed that 16 of 36 farmers experienced different operating problems related to cows and milk yield during the transition. The most common problem was lack of cows and heifers. Many farmers also realized that they should have raised more heifers and calves in the years before the transition. Cows were culled due to health problems, or problems with adapting to new routines and to the milking robot. Tukey's HSD test shows that the percentage of culled cows was significantly higher in year zero than later ($p<0.05$). While the average farmer culled 59.5% of the cows in year zero, one quarter of the farmers culled more than 69%. In comparison, the average culling rate in Norway in 2014 was 43% (Tine, 2014). It is also noteworthy that one quarter of the farms still had a low milk yield in year two, between 6,013 and 7,375 kg. Contrary, one quarter of the farmers managed to reach a milk yield of between 8,444 and 10,937 kg. Problems with culling and low milk yield of course affects the gross margin, and thus the farm net result negatively. Two male farmers in their thirties gave us an insight into what the problems in year zero are about:

> *"I my opinion one should not increase by more than 100.000 litres at a time, then you can fill in with your own heifers. Otherwise you easily make mistakes…. Buy too many cows which you should not have bought because they're the only ones you get hold of, slaughter too many cows….."*
>
> *"We have increased the production tenfold over the last 10 years, but it's not without pain you know, both in terms of costs of livestock and quota filling. The more gradually you can increase the production, the better."*

Our findings in this section supports hypothesis two that transition problems can explain discrepancies between budgets and accounts.

To sum up, milk delivery well beyond budgets, number of discussion partners, total gross margin, machinery costs and investment in machinery and buildings, deviation from building costs, farmers' risk perception, transition problems and too much effort in the building process, can explain the differences between the accounts and the budgets in this study.

The interviews revealed that 33 of 36 farmers think lender requirements was the main reason why they needed a whole farm budget. For 17 farmers another important reason was to feel confident that the investment was prudent. While 24 farmers felt they were involved in the budget process, only 10 had looked at the budget after year zero, and other family members were involved in the budgeting process on only half of the farms. Taken together our findings from the interviews and the differences reported earlier support hypothesis three, that whole- farm budgets to a small degree serve as a management tool, and that new tools are required.

4. Discussion And Conclusion

This study contributes to literature by identifying the causes of discrepancies between whole-farm budgets and accounts, and particularly the importance of managing the transition phase to avoid financial strain. Thus, our study differs from studies which are content to conclude that there are discrepancies, without explaining why and how they come about. Like Tanewski *et al.* (2000) we find that whole- farm budgets are conducted mainly due to lender requirements, and this can explain why they are rapidly out-dated and of little relevance as management tools. Thus, our findings are in line with some of the criticism against budgets common in the business literature (Bergstrand, 2009; Bogsnes, 2009, Hope and Fraser, 2003; Otley, 2003). However, it is likely that financing institutions will continue to demand whole- farm budgets also in the future. In line with Nergaard (1988) we therefore call for more careful budgeting processes, particularly more empirical data on fixed costs based on analyses of farm accounts. The discrepancies in fixed costs reported here are in line with the findings of Solberg and Haukås (2010) and Ruud- Wethal *et al.* (2012). In this setting it is noteworthy that the farmer's social network influences the level of machinery costs. This indicates that farmers discuss and learn about farm machinery and machinery costs from each other.

Our study also calls for more involvement from the whole farmer family in the budgeting process. Thus whole-farm budgets should include a verbal section where the family's goals and vision for the future are clearly stated. Beyond budgeting per se, we think RF can play a role as a new management tool to follow up the budgets in the critical first years after the investment. To be efficient, RF must be simple and implemented only for a handful of the most critical whole farm budget assumptions. The forecasts must also be relevant for the farmer at an operational level. Thus, RF can include e.g. milk yield per cow and milk income per month, quota filling, feed amounts needed and feed costs. RF can also be made for fixed costs, e.g. machinery costs. Combined with benchmarking with other farms, and quarterly updated accounts, we think this will increase the probability that the budget targets are achieved.

According to our findings there is reason to caution against a strong expansion of milk production beyond budgets, particularly when the expansion involves building investment. It is paradoxical that while the main investment in a cowshed is calculated in detail, subsequent investments take place more or less without any kind of budgeting. This may incur liquidity problems. To make budgets more realistic, a suggestion may be to allocate a fixed annual amount in the budgets for future unspecified investments, a practice already in use among some planners. Budgeting investments relates to our finding that the farmers' risk perception strongly influences the debt level. An interesting topic is how planners can take farmers' risk perception into account in practice, and here our findings call for more research. Models for farm stochastic budgeting takes risk into account (see Lien 2001, for an overview). While such models are not commonly used in practice in Norway, we think they can assist in making farmers more aware of the critical budget assumptions. Together with farmers the planners can enter the most likely range of e.g. the milk yield per cow, and show the effects on the gross margin for the whole range. This can help avoiding transition problems.

This study shows that many farmers struggle to grow and increase the milk yield and the number of cows simultaneously, supporting the findings of Davey and Nettle (1997), Alvarez and Arias (2004), Davidsson *et al.* (2008) and Sipiläinen (2008). We add to this literature by showing that if farmers spend too much effort on building the cowshed, this hampers the milk production in subsequent years, and thus increases the financial strain. Therefore, farmers should consider carefully whether they should participate in the building process themselves, and if so, by how much. For farmers with little experience with building processes, it might be a better idea to hire a construction manager to manage the process. This might also reduce the risk of increase in short term debt due to budget overrun. To deal with the challenges in the transition phase a mentoring program could be set up, allowing farmers who have undertaken investments to guide other farmers. Thus many farmers can benefit from increasing their social network, both to avoid transition problems and to keep machinery costs under control.

Based on Hansen and Jervell (2014) and our findings, we suggest dividing farm expansion into three phases: I) planning II) transition, and III) a new-operational phase. In the new-operational phase, practical implementation of and further development of new routines to meet the production targets are important tasks. These are quite different tasks compared to the more abstract planning phase. In the planning phase focus should be on e.g. involving the whole family and a decision on own efforts in the building process. Further, thorough planning of all necessary investments included outdoor machinery is necessary to avoid budget overruns and increase of short term debt. Similarly, concrete plans should be made for how to increase milk yield, how to get enough forage, cows and milk quota, and which cows to cull. Thus, the planning phase needs to start approximately two years ahead of the investment. In the transition phase, working on and monitoring building of the cowshed, smooth introduction of the cows to the new environment, e.g. directly from pasture, and developing new routines are important managerial tasks. Looking for cows which do not get milked or do not visit the feeding stations regularly are practical examples. Changing focus from looking at individual cows to looking also at herd averages is a challenging task for many farmers in this period. We think this tripartite division will put both farmers and planners in a better position to deal with the different challenges reported here.

The farms in this study are larger than today's average farms in Austria and Switzerland, as well as in many countries in Eastern Europe, Latin America and Asia (IFCN, 2015). Thus, our results should be of interest also to an international audience of farmers, planners and lending institutions. The study was conducted in Norway only, and future studies should therefore include farms in wider geographical area. Future research could also explore more in-depth what characterizes farmers who manage large changes well.

To conclude there are huge discrepancies between budgets and accounts after only two years, particularly in fixed costs, investments and debt. Little ownership of the budget, increase in milk production beyond budget, transition problems, too much effort in the building process, unplanned machinery and building investments, deviation from building cost estimates, number of discussion partners, gross margins and farmers' risk perception can explain the discrepancies. To secure a financial viable farm expansion we suggest dividing the expansion process in three different phases, and the implementation of mentoring schemes. More empirical accounts data for budgeting are also called for. According to this study whole farm budgets are not commonly used by farmers as a management tool. Rolling forecasts represent a promising tool to follow up whole-farm budgets, combined with benchmarking and quarterly updates of the accounts.

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Acknowledgement

The authors wish to thank Klepp Rekneskapslag SA for participation and cooperation in the project, Hå Rekneskapslag for facilitating the accounts, and Rekneskapslaga i Dalane for participating in the project on which this study rests. Thanks to Fylkesmannen i Rogaland - Landbruksavdelinga, Jæren Sparebank, Sparebank 1 SR-Bank, Sparbanken Vest and Haugesund Sparebank for funding the study. Thanks to Terje Øen for initiating the project, and to Tone Øen for transcribing the interviews. Thanks also to Andrè Brockstedt Myrseth for facilitating the herd dataset.

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REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-50

Domestic livestock in Nepal: production systems, genetic resources, research and the way forward

R. TREVOR WILSON[1]

ABSTRACT

This paper describes the major characteristics of Nepali small farm production systems with particular reference to livestock and their feed supply. The current and potential contributions of the livestock sector to human welfare, to household income, to food security and to overall biodiversity are also assessed. Nepal's animal genetic resources are extremely diverse (at least 17 species) and have multiple functions. They are yet to be fully characterized but the received wisdom that they are unproductive and of inferior genetic merit is not founded on comparative research or on the several production objectives (including adaptability to the local environment) for which animals are kept. Research in the past has been along classic lines, carried out on station and not always related to the real problems of small farmers. Future research areas should be identified in collaboration with farmers and the extension services, should be mainly applied and adaptive in nature and should be carried out in collaboration with farmers on their farms (On Farm Technology Testing) as well as on research stations.

KEYWORDS: domestic animal biodiversity; smallholder production; food security; research; livestock production objectives

1. Introduction

On a global scale Nepal is a geographically and economically insignificant landlocked country compressed from the north by China and from the west, south and east by India. In its small area, however, it rises from a few metres above sea level on the Indo-Gangetic Plain to the soaring heights of the Himalayas that culminate in the earth's highest point at the peak of Mount Everest over a horizontal distance of less than 200 km. Within its territory of 147,181 KM^2, the nation's projected 2015 population of 28.0 million people (CBS, 2016) live in several physiographic regions and many agro-ecological zones. The Human Development Index (HDI) is very low at 0.428 (UNDP, 2010), putting Nepal 138th in a league table of about 180 nations. Per person nominal Gross Domestic Product (GDP) is US$ 785 (CBS, 2016). Growth in overall GDP was 4.9% during the period of the Eighth Development Plan (1992/1993-1996/1997), 3.6% during the Ninth Plan 1998/1999-2000/2001), 3.4% during the Tenth Plan (2001/2002-2006/2007) and 4.5 per during the Three Year Interim Plan (2007/2008-2009/2010). Over these periods agricultural sector growth rates were lower than the overall at 3.0% (Eighth Plan), 3.3% (Ninth Plan), 2.7% (Tenth Plan) and 3.2% (Interim Plan). Projected rates of increase were not achieved for various reasons but especially due to political instability overshadowing economic issues from the mid-1990s, uneasy labour relations and weak infrastructure (NPC, 2011).

Agriculture employs 67% of the 11.2 million over 15 years old of 'currently employed people': 56% of males and 77% of females work in the sector (CBS, 2009). Livestock and their products contribute greatly to the empowerment of women and other marginalized groups (Bajracharya, 1994; Gurung *et al.*, 2005; Parajuli, 2008). More than 35% of national GDP was derived from agriculture in 2011 – down from almost 48% in 1991, reflecting the growing importance of the service sector and especially tourism (NPC, 2011). Livestock production contributes 31% of agricultural added value and more than 16% to total GDP (CBS, 2014), not accounting for the value of draught power and manure. Animals and their products provide about 20% of household cash income. Livestock support to total household welfare is greater than this simple number indicates due to the value of home consumption. In the mid-1990s the proportion of livestock to total agricultural output was expected to increase from about 30% to 45% over the 25 years to 2020 (NPC, 1995) and the cereal deficit was expected to continue to worsen (Thapa and Rosegrant, 1995). The increase in livestock contribution was to be driven by annual growth rates of 2.9% to 6.1% during the Plan period but the targeted growth was not achieved (Pradhanang *et al.*, 2015).

Original submitted March 2016; revision received March 2017; accepted July 2017.

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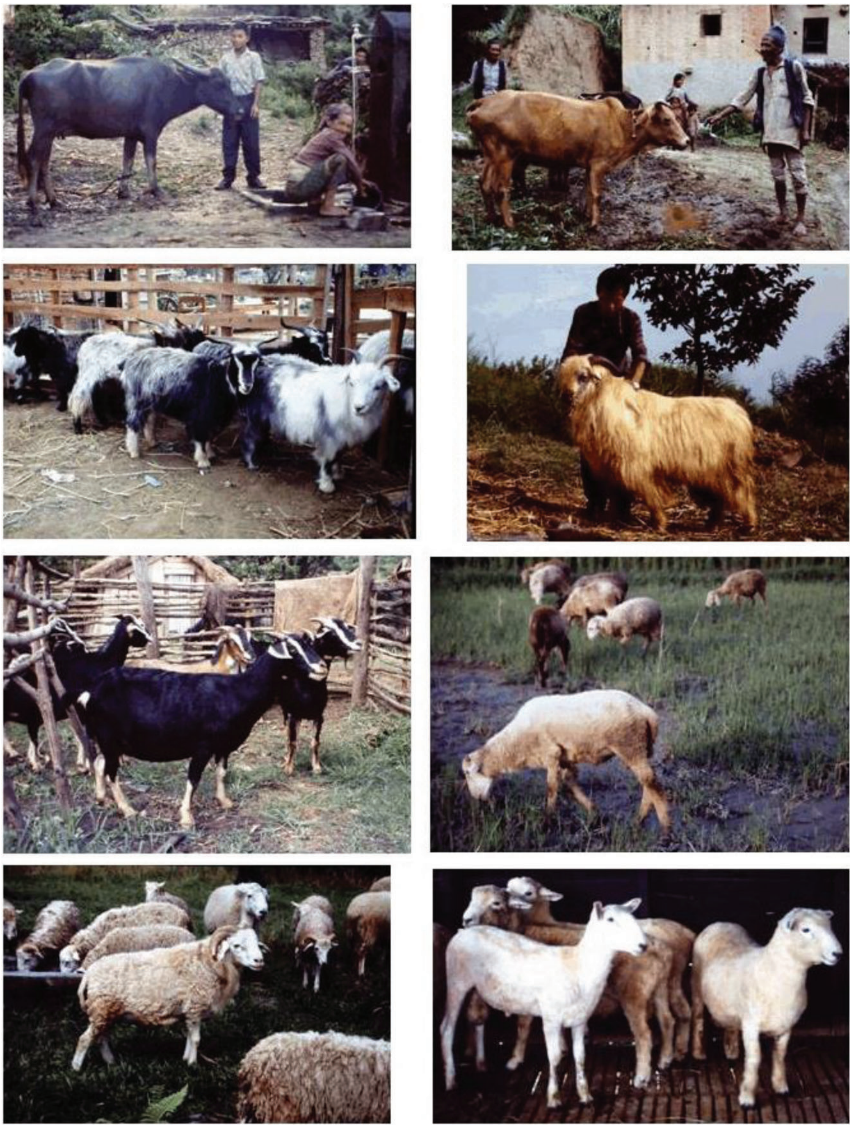

Figure 1: Domestic animal diversity in Nepal – 1 (from left to right, top to bottom) (a) Buffalo heifer at Baramche (1750 m) with its young friend, (b) Nepalese Hill zebu cattle at Rabiopi in Kavre District, Central Region, (c) Tibetan Dwarf goats for sale at the Dashain festival in Kathmandu, (d) Sinhal male goat at the Bandipur Goat Farm of the Nepal Agriculture Research Council, (e) Khare goats selected for colour type at the Bandipur Goat Farm, (f) Lampuchre sheep grazing a rice stubble in the Terai, (g) Kagi sheep at the Lampatan Production Farm, Pokhara, western Nepal, (h) Romney Marsh and Leicester rams from New Zealand on a Government stock farm at Pokhara

Domestic animals in Nepal contribute greatly to the country's already plenteous biodiversity (See Figure 1 and Figure 2).

Livestock include cattle (7.2 million head in 2012/2013), buffalo (5.2 million), goat (9.8 million), sheep (809,000), poultry (48.0 million fowl, 376,000 ducks, 1.5 million pigeons and 52,100 'other' birds), yak and yak-cattle crosses (48,865)[2], pig (1.2 million), equines (23,340) and meat and fibre rabbits (24,240) (MOAD 2013; CBS, 2014). Milk from buffalo (1.2 million tonnes) and cows (492,400 tonnes) is the major livestock product. About 26% of all buffalo and 14% of cattle are lactating at a given time. Buffalo, cattle and yak milk is also converted to cheese, ghee, butter and other products. Buffalo (175,130 tonnes) produce most meat, followed by goat (55,580 tonnes), domestic fowl (42,800 tonnes), pig (18,700 tonnes), sheep (2,720 tonnes) and duck (217 tonnes) (MOAD, 2013): it is illegal to slaughter cattle but some clandestine killing takes place. Some 87.4 million hen eggs and 13.0 million duck eggs were produced in 2012/2013 as well as 588 tonnes of wool (MOAD, 2013). Despite the importance of livestock and the food they provide, consumption per person of the major comestibles is lower than basic needs. Milk availability from domestic resources in 2013 was estimated to be 72.1 litres per person with meat availability being 11.8 kg (NPC, 2013).

Draught is often neglected in assessing livestock's contribution to welfare and the national economy (Abington, 1992). More than 75% of crop land is ploughed by oxen or buffalo. In 1984 it was estimated that livestock produced 1.37 million kilowatts of energy, valued at Nepali Rupees 1300 million (US$ 65 million at that time) (Oli, 1985). The value of power used in other agricultural operations, particularly threshing, and in transport (even goats are used as pack animals in the Hills) should be added to this amount. Further added value derives from livestock manure which, until recently, has been together

[2] In Nepal 'yak' usually refers, in addition to the species, to male animals, 'nak' being used for the female: Yak-cattle crosses are usually referred to as 'chauri' but there are many other names for various levels of hybridization.

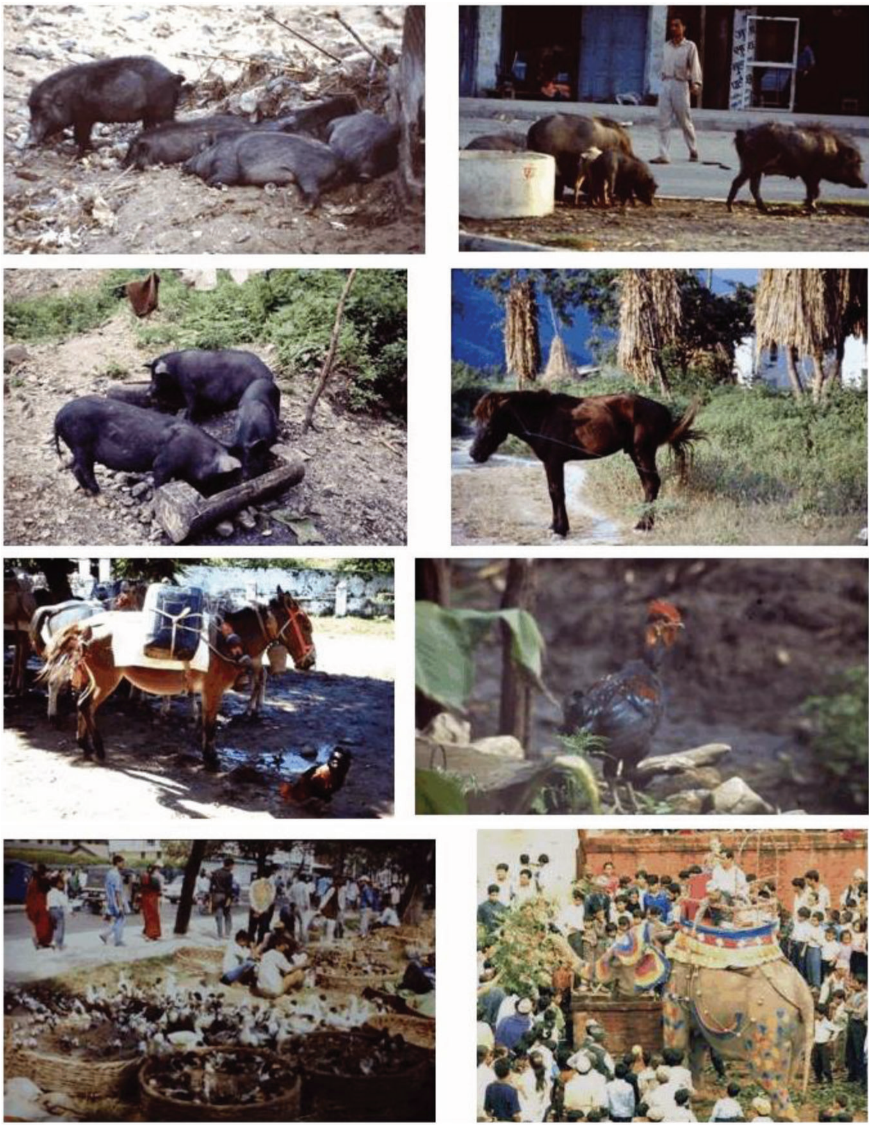

Figure 2: Domestic animal diversity in Nepal – 2 (from left to right, top to bottom) (a) Chwanche pigs resting in shade on a river bank, (b) Hurra pigs scavenging in a Terai town in eastern Nepal, (c) Pakhribas pigs on a smallholder farm, (d) A Terai pony in use by the Nepalese police in Ramechhap district – note stored crop residues in trees, (e) Mules loaded with diesel fuel and grain in Damao, western Nepal, (f) Naked neck Sakini chicken in western Nepal, (g) Mixed species of domestic poultry on sale in a main thoroughfare in Kathmandu at the October Dashain festival, (h) Elephant being prepared for a ceremonial occasion in Bhaktapur

with some composted crop and household residues the sole source of the essential nutrients required for crop production (Takeshima *et al.*, 2016). At the beginning of the 21st century it was estimated that cattle and buffalo produced 33 million tonnes of manure every year which, if all collected would have been valued at USD 58.75 million.

In addition to its use in ameliorating soil fertility and structure dung is used as a fuel by 9.8% of all Nepali households (Joshi, 2002, cited in Rushton, 2009). ''The application of farmyard manure is the traditional and dominant method used by farmers to maintain fertility'' (Ransom *et al.* 2001. p.274). Application of farmyard manure in five time series of on-farm topsoil monitoring over periods of one to three years increased organic matter from 3.3% to almost 3.8%; total nitrogen levels were significantly improved and the enhanced soil organic matter status was reported to improve structure, workability and moisture characteristics (Bishwarkama *et al.* 2014). In the Terai heavy applications of farmyard manure helped to maintain soil fertility and residual levels were sufficient to supply plant nutrients in legume rotated systems (Ojha *et al.*, 2014).[3]

This paper describes the major characteristics of Nepali small farm production systems with reference to indigenous livestock and the research undertaken in the country.

2. Production Systems

Nepal has a great diversity of agroecosystems in relation to its absolute physical area. Altitude, precipitation, temperature, humidity, soil, slope and aspect combine to provide a microcosm of the earth's vegetation types and farming systems. Small farms dominate the sector (Table 1), 22.0% being less than 0.2 ha in area and 31% between

[3] The Terai is a lowland plain that lies across the whole of southern Nepal bordering India at an altitude of between 67 and 300 m: in its natural state it is characterised by tall grasslands, scrub savannah, sal forests and clay rich swamps but in the Nepal of today it is densely cultivated.

Table 1: Number, area and fragmentation of holdings by total area of holding in Nepal

Holding size (ha)	Holdings				Average number of parcels
	Number	%	Total area (ha)	%	
<0.1	355,549	9.56	20,076.5	0.80	1.5
0.1-<0.2	461,957	12.43	68,161.8	2.70	2.1
0.2-<0.5	1,169,503	31.47	396,720.9	15.73	2.9
0.5-<1.0	984,022	26.48	695,060.1	27.55	3.7
1.0-<.2.0	548,974	14.78	749,810.0	29.73	4.5
2.0-<3.0	129,364	3.48	308,568.5	12.23	5.2
3.0-<4.0	39,507	1.06	134,353.1	5.33	5.6
4.0-<5.0	14,881	0.40	65,364.7	2.59	6.0
5.0-<10.0	10,744	0.29	69,177.1	2.74	6.1
⩾10.0	1,054	0.03	15,227.2	0.60	6.8
Total	3,716,555		2,522,519.9		3.2

Source: adapted from CBS, 2013

Table 2: Livestock density (head/km^2) on cultivated land in Nepal

Physiographic unit	Total Livestock Units (million)[1]	Species					
		Cattle	Buffalo	Goat	Sheep	Pig	Poultry
Mountains	2.18	318	120	321	153	30	483
Hills	7.44	217	119	208	27	21	431
Terai	4.05	171	71	107	10	12	192
Nepal	13.67	206	98	174	30	18	333

[1] Livestock Units (equivalent to 250 kg live weight) are preferred here to overall numbers as they allow weighting of all species to a common denominator.
Source: DFAMS, 1990

0.2 and 0.5 ha so that more than half of all farms are less than 0.5 ha (CBS, 2013). The 115,538 landless holdings represent just over 3% of all holdings.[4] In spite of much notional encouragement by Government for commercialization, production is largely for subsistence due to low product prices with no competition among traders and difficulties of access to markets walking up and down the steep hills for distances of up to 20 km (Ransom *et al.*, 2001).

Some 68% of the country's 3.7 million agricultural holdings keep an average of 2.82 cattle, 49% keep an average of 1.90 buffalo, 70% have 4.67 goats, 3% own 6.32 sheep and 0.2% own 7.84 yak and yak-cattle crosses. Of non-ruminant livestock, 13% of households own an average of 1.84 pigs, 0.3% own 1.84 horses, 0.04% own 4.35 donkeys and/or mules and 0.2% own 3.88 rabbits. Domestic fowl are owned by 54% of households with an average flock size of 14.52 birds: indigenous fowl are owned by 52% of households each with 8.60 birds whereas improved birds are kept by 3% of units with an average of 103.71 birds and in this 'commercial' sub-sector broilers are about 2.5 times as numerous as layers. Ducks are owned by 3% of households with an average flock size of 3.95 birds and pigeons are owned by 5% of household who each have an average of 8.73 birds. More than 56% of cattle are male whereas 22% of buffalo are male as are 33% of yak, 31% of goat and 34% of sheep (Sherchand, 2001). Among traditional poultry about 13% of birds are males and 87% are females. The annual amount of labour devoted to livestock is 51 days in the Mountains, 73 days in the Hills and 64 days in the Terai (MOAD, 2013; CBS, 2014).

[4] Holdings of less than 0.01355 ha in the Terai or less than 0.01272 ha in the Hills and Mountains under crops are considered landless (CBS, 2013).

Livestock are major features of all farming systems. They are, however, more important in the Hills and Mountains where their numbers greatly exceed those of the Terai (Table 2) and where densities per unit of cultivated land are much higher. Households in the Mountains own 11.8 livestock units, in the Hills 10.3 units and in the Terai 5.0 units. More than 60% of buffalo, 50% of cattle, 57% of goats, 43% of sheep and 61% of pigs in addition to 73% of poultry are located in the Hills (MOAD, 2013). High numbers of animals here result in substantial feed deficits, especially during the winter period. At this time of the year animal feed derives mainly from stored crop residues (see, for example, Figure 2d which shows maize stover stored in trees) which provide 16% of total livestock feed and which are distributed to animals around the house compound. In the initial phases of the 'green revolution' rice varieties with short straw were rejected by farmers in favour of the traditional long-straw types which provided more livestock feed (Shrestha, R. K. 1988). In spite of government incentives uptake of higher yielding varieties has continued to be low and the "most popular varieties were those not recommended by science and policy and were disseminated farmer to farmer" (Uprety, 2016 pvi): Nepal is still a net importer of rice (Bishwajit *et al.*, 2013).

Small farm mixed systems reveal great complexity (Devendra and Thomas, 2002; Devendra *et al.*, 2005). Interactions among crops, forest and livestock (Figure 3), include:

- holdings are small and fragmented;
- several animal species are kept and many crop types are grown;
- on and off farm including forest resources are used;

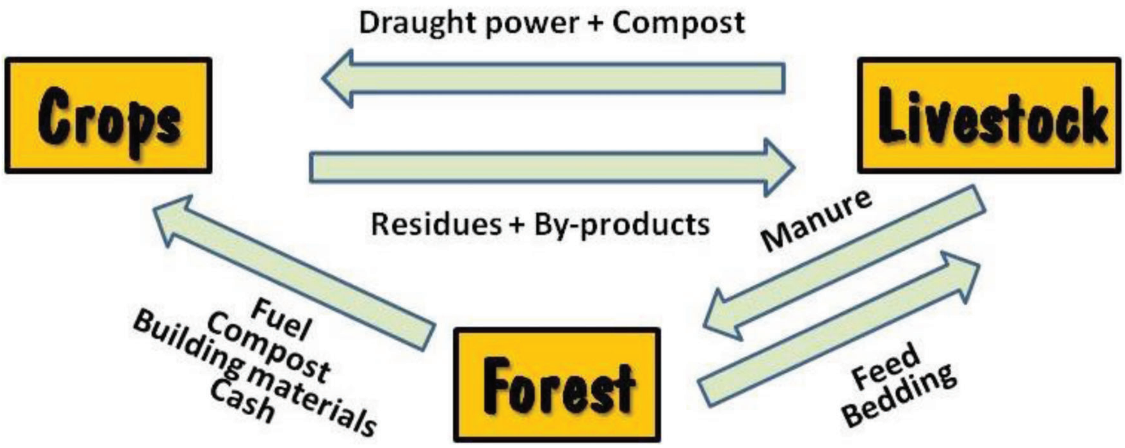

Figure 3: Main component interactions of small farm systems in Nepal

- livestock feed resources are sourced from on and off the farm;
- people have little education;
- there is poor access to services and low use of technology and inputs;
- farms are isolated and far from markets;
- production is diversified as a strategy for risk reduction;
- there is little or no desire (nor much incentive) to maximize production; and
- production is mainly subsistence oriented.

Risk avoidance strategies add to the problems faced by livestock themselves: for example, reduced crop yields and smaller cropped areas drive people to seek outside or migratory labour opportunities. Feed supplies, almost always limited in quantity and quality, are put under pressure. Traditional skills with regard to crop mix, crop varieties, planting dates and pest control are no longer adequate to cope with new problems created by climate change (heavy rains, prolonged droughts and reduced yields due to temperature effects) and high human population densities and resultant overstocking with livestock (Sujakhu *et al.*, 2016). Nutritional inadequacies are linked with health problems, especially general debility caused by internal and external parasites and endemic subclinical disease (Rai *et al.*, 2000; Pradahang *et al.*, 2015): some parasites and diseases are also zoonoses (Devleesschauwer *et al.*, 2013; 2014), and have serious deleterious effects on people and on their ability to work.

Stock rely on residues (rice straw, maize and millet stover, stubbles) and by-products (rice husks, maize cobs, cereal brans, oil seed cakes, molasses) from rainfed and irrigated areas for much of their feed (Upreti and Shrestha, 2006). These resources, especially during the dry winter, are dietary mainstays. Even in systems where crossbred dairy cows are important less than 50% of total feed is fresh green material, much of which is garnered from weeds, field bunds and roadsides. Limited amounts of grown fodder include berseem (*Trifolium alexandrinum*) and leucaena (*Leucaena leucocephala*) (York, 2010) that are fed mainly in cut-and-carry systems. Crop land resources are complemented by limited grazing off it and further cut-and-carried grass and tree forage from surrounding (often distant) scrub and forest areas. There are almost constant shortages of feed because animal numbers are not matched to feed availability and stocking rates grossly exceed carrying capacities in most areas. Farmers therefore need to make choices regarding the priority of providing adequate feed to certain classes of 'productive' stock or feeding all classes at sub-maintenance (and no production) levels for most of the year (Gatenby *et al.* 1989).

3. Animal Genetic Resources

Farmers own few animals but several species (Shrestha, R. K. 1988; Wilson, 1996). Emphasis on one or other type of livestock depends on preference, social position, local ecology and market openings. Herding many species is a rational strategy for reducing risk but creates management problems and limits output of single products. Livestock belong to at least 17 biodiverse species, most comprising several 'breeds' (Table 3) (Epstein, 1977; Wilson, 1996; MOAC, 2004). There is as yet, however, no detailed 'catalogue' of breeds or types.

Livestock functions in Nepali farming systems are far more complex than the simple provision of milk and meat for human subsistence (Wilson, 1994). Such functions, several of which are intimately related to a sustainable farming system, can probably best be assigned to three major categories, defined as Immediate, Intermediate and Indeterminate (Table 4).

There has been little attempt to characterize Nepali livestock other than on morphological, functional or locational grounds. Little that is objective can, therefore, be said about their potential. In goats and sheep, for example, four breeds are recognized related to a general agroecological zone and production system (Table 5). Indigenous cattle and buffalo are preferred by most farmers because of better adaptability across agro-climatic zones, ability to digest low-quality feeds and to survive on a low nutritional plane, cold tolerance and smaller body size (Paudel, n.d.): local animals also have better resistance to local diseases and to internal and external parasites. The three indigenous pig breeds constitute 58% of the total pig population and are important to Nepal's rich biodiversity of livestock resources but risk extinction because of official policy to replace them with exotic and supposedly 'improved' animals (Nidup *et al.*, 2010). Most native fowl are ascribed to 'sakini' (although Ghanti Khuile and Puwakh ulte are sometimes mentioned) but cursory inspection of a district flock shows many variations -- some normal, some with bare neck

Table 3: Domestic livestock species and indigenous breeds in use in Nepal

Ruminants		Non ruminants	
Species	**Breeds**	**Species**	**Breeds**
Buffalo	Lime, Parkote, Gaddi	Pig	Chwanche, Hurrah, Bampudke
Cattle	Terai, Lulu, Achhami, Pahadi, Khailla	Horse	Tuli
Goat	Terai, Khari, Sinhal, Chyangra	Donkey	(+ Mule)
Sheep	Lampuchhre, Kage, Baruwal, Bhyanglung	Rabbit	
Yak	(+ plus Yak-Cattle crosses)	Elephant	
		Domestic fowl ("chicken")	Sakini, Puwankh Ulte (Dumse), Ghanti Khuile
		Other poultry (Pigeon, Common duck, Muscovy duck, Chinese goose, Guinea fowl, Turkey)	

Source: Compiled by the author from Epstein, 1977; Wilson, 1996; MOAC, 2004

Table 4: Immediate, Intermediate and Indeterminate products of Nepali livestock

Immediate	Intermediate	Indeterminate
milk meat eggs fibre hides and skins feathers	farm draught power on and off farm transport industrial applications (oil mills, etc) manure as fertilizer dung as fuel and for biogas production weed control	reduction and spread of risk from crop operations generation and accumulation of capital generation of income and smoothing out cash flow fulfilling social, cultural and religious needs and obligations providing status or "prestige" in the immediate community empowering women (control of milk sales, sale of eggs to provide cash income) culture, sport, recreation and companionship

Source: Compiled by the author

Table 5: Distribution and management of goat and sheep breeds in Nepal

Goat		Sheep		Physiographic region	Altitude (m)	Climate	Management system
Breed	**Per cent of total**	**Breed**	**Per cent of total**				
Chyangra	6.0	Bhanglung	4.0	Mountain	> 2500	Cool temperate/ subalpine	Sedentary/ transhumant
Sinhal[a)]	35.0	Baruwal	41.0	Mountain	> 2500	Cool temperate/ subalpine	Transhumant
Sinhal		Baruwal	22.0	Mid Hill	1500-2500	Warm temperate	Transhumant
Khare	50.0	Kagi	21.0	Lower Hill	300-1500	Subtropical	Sedentary
Terai	9.0	Lampuchre	12.0	Terai	< 300	Subtropical/ tropical	Sedentary

Note: a) The figure of 35% for Sinhal goat is the combined percentage in both physiographic regions.
Source: MOAD, 2013 plus author's analysis

and some with frizzle feather genes -- all of which are likely to have their own production and adaptability characteristics (Shrestha, 2014). Outside the main urban areas scavenging indigenous poultry – which comprise 58% of the total poultry population – are preferred because they require little attention and do not require the expensive buildings feed and veterinary care of modern breeds (Kattel, 2016). There is an undoubted need to conserve some of these resources but it must be remembered that 'conservation' includes preservation and use and there should be no intention of creating a living museum.

Domestic livestock are rarely kept for a single production objective and adaptation to the local environment is an important function. General remarks in some reports about livestock productivity being limited by their genetic potential (eg IFAD, 1990) are neither meaningful nor helpful. Increased productivity, because of the multiple role in the economy and in family life, is part of a complex process. It will not necessarily derive from 'upgrading' and 'improving' of native stock by crossing with supposedly superior exotics. Nor will it be easy to upgrade animals to yield more or better-quality manure, a product often stated to be a main purpose of keeping livestock in Nepal. Improved productivity in the short to medium term is more likely to stem directly from improved nutrition, health and management.

Table 6: Summary of research publications in Nepal by species and subject area

Livestock species	Subject area (number of pages)				Total
	Health	Nutrition	Breeding	Production and management	
Cattle, buffalo and yak	40	19	28	31	118
Goat and sheep	20	12	18	21	71
Pig	4	3	8	8	23
Poultry	11	10	2	12	35
Rabbit	1	2	0	6	9
Total	76	46	56	78	256

Source: compiled by the Author from Tiwari *et al.*, 2011

This does not mean that ways to improve the inherent value of local types should not be sought concurrently and that characterization should not be a major element of the process. In pursuing this policy, however, consideration must be given to comparative advantage and economics. If, for example, India produces animals for socio-economic and ecological conditions similar to those of Nepal, what is needed is adaptive research on these animals to determine their suitability. Similarly, if it is cheaper to import wool for the carpet industry from New Zealand than to produce it locally, research effort should concentrate on something in which Nepal has comparative advantage.

4. Research

A great deal of research has been undertaken on the domestic livestock of Nepal. A compendium of documents published in Nepal in the 30-year period 1980-2010 (Tiwari *et al.*, 2011) shows that most work was on bovines, most was on health and disease problems (Table 6), most was on very few animals and of very short duration and most was of an *ad hoc* nature[5].

Indigenous domestic livestock have received little respect or consideration from research and development bodies in Nepal although there was some interest in their use and conservation during the 1990s and early 2000s (Sah and Joshi, 2003). The apparent policy – in large part driven by international donors and non-Governmental Organizations – has usually been to upgrade and replace native stock by 'improved' breeds. In the early twenty-first century the Department of Livestock Services of the Ministry of Agriculture and Cooperatives had 11 farms undertaking research and the National Agricultural Research Council had nine (MOAC, 2004): the main thrusts of research, without exception on all of these farms) was were on exotic breeds and replacement of indigenous ones.

Official policy – if indeed 'policy' is the correct word – for buffalo has been to upgrade and replace local varieties by crossing to Murrah bulls by natural mating or by Artificial Insemination (AI). Jersey and Holstein-Friesians are the main exotic cattle breeds with most recent imports being from India. Semen of these, and of Ayrshire and Brown Swiss, is nominally available via an AI service. Except in accessible pockets, however, there has been little success with AI and the impact on native stock has been minimal. Only 2-5% of the livestock population has been touched by these programmes. In the late 1980s there were 117 AI centres in 34 of the country's 75 districts, 71 being in the Hills, 43 in the Terai and only 3 in the Mountains. Most semen was then imported from India. In 1989, 2951 doses of frozen and 4319 of 'warm' semen were available and 60% of this was distributed to the Terai. Only 20% of the semen was used and the average number of inseminations per month (cattle and buffalo combined) was less than eight. Conception rates were about 30% to first service. Animals thus still need to be inseminated several times and farmers usually quickly revert to natural service (ADB, 1992; York, 2010). In 2004 the uptake of AI was still less than 1% (Shrestha, 2004) and there is still no evidence in support of productivity being improved through genetic improvement of dairy animals. Increases in total milk production can be attributed to increases in the number of animals (Paudel and Shah, 2010).

One fashionable and constantly recurring activity is the allocation of a bull to a farmers' group (Gurung *et al.* 1995; Shestha and Amatya, 2004). It has had mixed but usually limited success. A major problem is the cost of keep (in spite of occasional Government subsidy) to a small farmer with limited feed resources. This is compounded by the reluctance of other farmers to pay an economic price for the service fee. Development projects often provide free or highly subsidized exotic cattle in the milk catchment areas of the main urban centres but there is little indication that this process will be sustainable in the long term and following the termination of the projects in question[6]. Government maintains two breeding farms for yak. Numbers are low at both places and a very few animals are distributed to traditional owners each year. Breeding objectives are far from clearly defined and oscillate between pure breeding of yak and crossing with cattle to increase the ecological range of both species for smallholder use. 'Improved' white yak bulls have been imported from Tibet for use in 'upgrading' local animals (Kharel, 1995).

The goat has been subject to the archetypal upgrading and replacement by improved breeds. Breeds have been imported from many parts of the world. Jamunapari, Barbari and Beetal from India have been easiest to obtain and used most in formal breeding programmes. These breeds, especially the Jamunapari, are widely used by Terai smallholders. There is evidence of Saanen blood but it is not clear whence this came. Semen of Kiko (a New Zealand breed developed from feral goats for

[5] The compendium does not cover any research published outside Nepal by Nepali scientists nor does it include the limited number of articles published outside Nepal by international scientists.

[6] Formal support for dairy production, processing and marketing began in the early 1950s: there has since been continual, continued and continuing support in the form of technical assistance and financing from *inter alia* the UK, USA, Denmark, Switzerland, New Zealand and the World Bank, FAO, International Fund for Agricultural Development, Asian Development Bank as well as several International NGOs.

meat production from marginal areas) was imported by a UK aid project in 1989. As for other species, the presumption -- with no prior characterization -- has been that native goats need improving. In limited performance trials and in outreach programmes in farmers' flocks the native Khare has usually done as well as or better than its crosses with exotics (Neopane and Upreti, 2001). This is especially so in the composite trait of weight of kid weaned per female per year. The superiority is due to prolificacy, short parturition intervals and low mortality rates. Early maturity, while not measured in the composite trait, probably adds further to the superiority of the Khare. Formal programmes have had limited impact on local genetic resources. In the Terai, however, crossing of Indian with Nepali breeds is common practice among farmers and successful in terms of farmer acceptance. The breed most at risk is the Sinhal which is also crossed indiscriminately with the Khare in the higher Hills/lower Mountains. A small flock of Sinhal maintained at the Bandipur Goat Farm was perhaps the earliest – if temporally belated – official recognition that this breed was in danger and in need of conservation (Wilson, 1996).

Historically the conventional wisdom has been that Nepalese sheep are of low productivity and poor genetic potential (Pradhan, S.L. 1992). This mindset prevailed to some extent through the next 10 years (MOAC, 2004) and indeed has continued almost up to the present (Pradhanang *et al.* 2015). Official policy has been to improve native populations by crossing with exotics. Both wool (for the national carpet industry for which almost all wool is imported) and meat production are cited as goals. Introduced breeds have been brought from afar. The favourites have been Polwarth and other Merinos, including Merino d'Arles, Rambouillet and milk types. Performance of first crosses has usually been poor: wool yields have been raised under station conditions but reproductive rates have been low with less than 0.5 lambs per ewe weaned per annum. For meat, purebred Baruwal weaned 8.8 kg/ewe/year compared to 5.8-7.9 kg/ewe/year for crossbreds. Four Government sheep farms continue to import and cross exotic sheep on local types and some Romney Marsh and Leicester rams arrived from New Zealand in 1994 to reinforce the policy and a further batch of Romney Marsh and Kuport sheep were imported in 2014 (NMN, 2014). Outreach activities still stress the advantages of crossbreds in spite of much evidence to the contrary (Shrestha, 2006; Acharya *et al.* 2016). These endeavours are, however, very limited in scope both in terms of areas covered and numbers of animals distributed. The general extension service is poorly staffed and lacks the means of access to wider areas. With the exception of a few pockets close to breeding centres there has therefore been little impact on native sheep populations. There is, nonetheless, a real need for proper characterization of indigenous breeds which should be accompanied by at least a temporary halt to the unstructured programmes currently in vogue. There could then follow a more objective national sheep breeding programme within the framework of clearly defined national goals.

The domestic pig programme is based uniquely on exotic breeds. Two or more of these are crossed to produce types considered suitable for various Nepalese environments. The Pakhribas, bred in part to satisfy a local cultural need, is a case in point. Official policy is absorption and replacement of indigenous pigs by natural mating with improved (i.e. exotic) boars distributed by Government farms. The Large White (Yorkshire) and several Landrace starins are the most popular breeds but some Duroc have been imported from Malaysia (Kayastha 2006). Most pigs that leave Government farms are, however, reared for slaughter and not used for breeding by smallholder farmers. Even when used for breeding there is no effective support or monitoring by Government. Except in the Pakhribas command area, where as much as 15% of the village pig population is of the Pakhribas type, pig breeding and improvement programmes have had little impact (Joshi, 2008).

A very few donkeys have been imported from India and Tibet in the past for mule production (Pradhan, S. M. 1992). Tibetan jacks were considered better as they were bigger and better able to mount horse mares. The Government of China also made a gift of 15 male donkeys in 1983. In effect, however, there are no organized breeding or conservation programmes and little to no official interest in equine development or conservation.

The usual 'improvement' package applies to scavenging chickens. Replacement and crossbreeding is based on multiplying layer lines -- New Hampshire, Black Australorp and White Leghorn -- on Government farms. Pakhribas breeds the Indian Giriraja (= Mountain King, a synthetic derived from Rhode Island Red and White Wyandotte) for the scavenging system, ostensibly due to disease resistance. It is liked by farmers for its colour variety but large size (cocks 6 kg, hens 4+ kg) may be a disadvantage in extensive systems. As many as 250,000 birds annually have been distributed to smallholders but the programme's impact has been insignificant. There is no Government follow up to distribution and exotic or crossbred birds are not usually given better feeding, health care or management than local ones. Farmers generally show little interest in supposedly better poultry: in the Pakhribas command area only 1.4% of birds were considered to be cross or pure-bred exotics, a figure that should be compared with 15% of improved pigs in the same area (Shrestha, 2014).

The lack of change in native chicken populations does not apply to urban and peri-urban areas. Where there is a strong and assured market for meat and eggs change has occurred. There are an estimated 15,000 small commercial units of up to 400 layers each and other small broiler units near Kathmandu and Pokhara. Some private hatcheries import parent stock from the USA and Europe and supply sexed day olds to smaller producers. Under good Nepalese management hen-housed averages are 190-260 eggs/bird/12-month cycle for layers and 1600 g at seven weeks for broilers. There is vertical integration in units which mix their own feed, use AI for breeding, rear their own birds and have their own market channels and outlets. Most eggs and birds in Kathmandu, except for sacrificial and festival occasions, are supplied from small or large commercial units (Acharya and Kaphle, 2014).

Eight Government fish farms should breed ducks to supply farmers and to develop integrated duck fish systems. In 1994 only one farm produced ducks (the Khaki Campbell was abandoned after two years as farmers had no interest in its light weight and supposedly superior egg laying). Reduced mature weights and annual

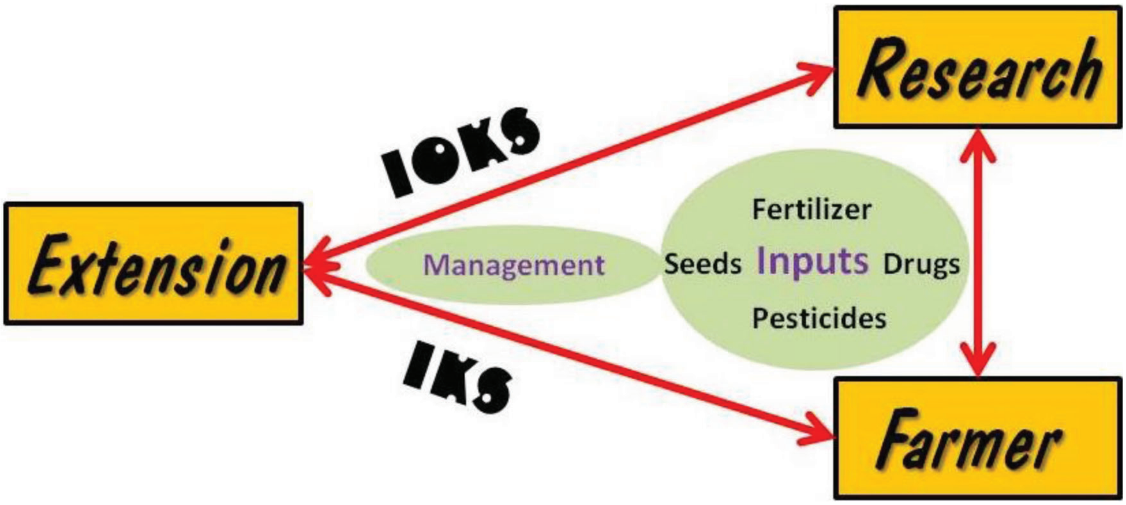

Figure 4: A model of research-extension-farmer linkages in an agricultural knowledge system

egg output of 60 eggs (against 140-150 just after import) on Government farms are considered due to lack of new blood and consequent inbreeding. There are no programmes for other avian species.

5. The Way Forward

There is evidence of a change in thinking in the research and development establishments, for example: "It will be very useful to strengthen and consolidate the participatory approach (PVS and PVB) by broadening that participation in our endeavors [through the] Outreach sites of NARC [which] are the focal points where the extension program and farmers interface with research" and "I would like to call on development supporters and colleagues to place the beneficiaries at the center of their activities. This will also be NARC's approach in framing our research and development strategies." (Sapkota, 2001, pp1-2).[7] Research is, nonetheless, still carried out mainly on station and some of this is still related more to researchers' interests than to real and farmer-identified problems. There is, however, following Sapkota's policy statement more openness and a willingness to work more closely with farmers.

Remaining problems include limited highly qualified manpower (although this situation is changing almost daily) and extremely limited material and financial resources (which may not change as rapidly as desirable in the foreseeable future).

Research in the past was along classic lines: scientists perceived a problem and attempted to solve it under controlled conditions on a research station. There was little to no interaction with the extension services, certainly no appreciation of farmers' problems or needs, and no testing of 'solutions' under the real-life conditions of small, fragmented and resource-poor Nepali farms. If production objectives have been defined -- and this has rarely been the case - they may possibly have been of a general nature such as the production of a buffalo cow that might produce 900 litres of milk in 305 days. The objectives have assumed that management would be of a reasonable standard, that a balanced and sufficient diet would be fed and that there would be good health coverage. Production objectives must now be redefined to something such as 'to produce a buffalo cow capable of a lactation yield of 900 litres of milk in 305 days under farm conditions where management is of a low standard, where there is a variable feed supply, where adequate veterinary care is not available and where the absence of males for long periods might lead to late ages at first parturition and long intervals between parturitions'.

Future research must take account of these lessons. Farmers are neither peripheral to nor divorceable from research. Nor are they simple clients but an integral part and a full partner in the research and development complex (Figure 4). Research-extension-farmer linkages are essential whatever the level of intensity. They become even more important as productivity improves. Men and women farmers (Bajracharya, 1994) are an integral, indeed a key, part of the Research-Extension-Farmer triangle. Knowledge flows in all directions and all parts of the knowledge system (indigenous knowledge system IKS of farmers and indigenous organized knowledge system IOKS of scientists) must be aware of and appreciate the skills of the others. Only by using this methodology will farmers benefit technically and economically from the results of research and will scientists achieve intellectual satisfaction.

The potential opportunities for improving livestock production in Nepal appear to lie in:

- training of farmers to improve management skills;
- manipulating input/output ratios;
- optimum use of land and livestock;
- use of improved and adapted technology;
- strengthened and integrated support services; and
- appropriate institutional and policy issues.

Taking into consideration these points and the limited resources available to Nepal, future research should be carried out:

> **on station** applied and adaptive research on relevant themes from areas with similar socio-economic and agroecological environments; and

> **on farm** adaptive research and on-farm technology testing (OFTT) of relevant interventions in partnership with farmers.

Some possible relevant technologies for OFTT (in no way exclusive or restrictive but which take account of

[7] R.P. Sapkota was Executive Director of the National Agricultural Research Council at the time.

many of the real constraints to improved productivity including the major seasonal feed shortages) might include the effects of:

- readily available rumen protein and energy (UMB) on weight gain of weaned goats;
- nutrition in late pregnancy on fertility, birth weight and kid mortality in goats;
- protein and energy (UMB) supplements on milk production of buffalo;
- early nutrition on age of buffalo at first conception; and
- use of cold-brooder boxes on chick growth and survival to egg-laying.

Long term political unrest, weak programmes and policies and especially weak agricultural education, research and extension services have contributed to the fluctuating and slow pace of agricultural development. In the past agricultural extension services were essentially top-down. Educational programmes and services were planned at the Department of Agriculture or Department of Livestock Services headquarters. Most extension activities are now planned at district level and private sector organizations, NGOs and professional associations (such as the Nepal Agriculture Extension Association (NAEA) established in 1990) complement public sector interventions. This system of linkages is being encouraged for efficient delivery of agricultural services. Public-private partnerships are being promoted and in addition to public provision NGOs and Community Based Organizations (CBOs) are contributing to the education and training of farmers. Information and Communications Technology (ICT) tools such as mobile telephones, internet, radio and TV are increasingly available and being used to facilitate communication and enhance rural development. Training of extension workers on participatory services, provision of timely market information to farmers and producers, strengthening supervision of field staff and providing reward and recognition programmes to motivate extension staff to deliver superior work are some of the steps needed to encourage farmers to produce food and to improve their skills (Ganesh Kumar *et al.*, 2003; Garforth, 2004; NARC, 2010; Murari and McNamara, 2011; Sharma, 2011).

About the author

Trevor Wilson is a practical farmer (retired) who bred pedigree Ruby Red Devons for many years. He is also an independent consultant on the environment and agriculture specializing in developing countries and with an emphasis on domestic animal genetic resources and livestock production. He was Director of the International Livestock Research Institute's West African Arid and Semiarid Zones Programme and Research Director of a specialist group at ILRI's headquarters in Addis Ababa, Ethiopia. He spent several periods in Nepal, that experience leading to the writing of this paper.

Acknowledgements

I am grateful to two anonymous referees for comments on an earlier draft of this paper.

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REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-62

Competitive advantages and disadvantages of agriholdings and independent farms – a case study from Ukrainian arable production

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ABSTRACT

This article analyses the competitive advantages and disadvantages of agriholdings and independent farms in Ukrainian arable production using expert-based focus-group discussions and comparing typical farms with a cost-of-production approach. Agriholdings were found to have strong competitive advantages in access to and cost of capital, as well as more favourable input and output prices. On the other hand, they are less efficient, with lower yields and higher overhead costs than top-performing independent farms. At the bottom line, typical well-performing independent farms were found to generate a higher return to land than typical agriholding member farms of the same size. If agriholdings can overcome their efficiency challenge, the economic gap may close in the future. A likely way to accomplish this was found to be decentralization and strengthening of farm-level management.

KEYWORDS: agriholdings; corporate farming; competitiveness; transition agriculture; typical farms

1. Introduction

After the collapse of the socialist economic system, agriculture in the three large countries of the former Soviet Union – Kazakhstan, Russia and Ukraine – entered a severe crisis, with production declining throughout most of the ensuing decade. However, starting in the late 1990s, the trend in arable production has reversed and the region has transitioned from a net importer to a net exporter (Liefert and Liefert, 2012). Much of the revitalization of arable farming in the three countries can be attributed to the investment activities of agriholdings. Agriholdings are farming companies made up of multiple operations under a more or less centralised management. In Ukraine, the development of agriholdings has been very pronounced (Byerlee *et al.*, 2012).

During the farm crisis in the 1990s, a considerable part of Ukraine's farmland fell out of production (UKRSTAT, various) because a large number of insufficiently restructured former cooperative and state farms (*kolkhozy* and *sovkhozy*) lacked the liquidity to work the land (Liefert and Liefert, 2012). Hence, the demand for farmland was not particularly high in the past and competition for it was weak. Today, land rents in Ukraine are still very low in comparison with other regions with comparable productive potential (Byerlee *et al.*, 2012). In addition, until January 1, 2017, a moratorium banned sales of agricultural land. Since its implementation in 2001, national and international investors found ways to circumvent the moratorium – e.g. by buying shares of agricultural companies (The Oakland Institute, 2015). With the ongoing tensions through the Ukraine conflict, it is difficult to forecast to what extent foreign investments into large-scale Ukrainian agriculture will continue. In 2014, the land consolidation of large agriholdings had slowed due to the global and geopolitical environment (UCAB, 2014).

In order to assess which of the two organizational forms will be more competitive in the future, two questions arise: Which factors drive the competitiveness of both organizational forms, and how great are their respective effects?

This article is structured as follows: First, a short overview of agricultural development since 1990, including crop and animal production, and statistical background information about farm structure in Ukraine is given. A literature review of competitive advantages and disadvantages of corporate farming follows. Next, the methodology and data sources are presented. Finally, competitive disadvantages and advantages of agriholdings based on focus group discussions and typical-farm data are discussed. Conclusions drawn from the analysis are presented in the last part of the article.

Original submitted October 2014; revision received June 2016; accepted June 2017.

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2. Development of agricultural production and farm structure in Ukraine

Development of agricultural production

Figure 1 shows the development of Ukrainian agricultural production for selected crops from 1990 to 2014. One can observe a sharp decline in grain and leguminous crop production in the first years of the 1990s, recovering in the late 1990s and developing a substantial upward trend since 2003, surpassing the level of 1990 in 2011 with production of 56.47 million metric tons. Sugar beets have played a substantial role in Ukrainian crop production but did not recover to the same extent as grain or leguminous crops. The production of potatoes and vegetables was more or less stable compared with grains, leguminous crops and sugar beets. Apparently, the cultivation of these products has not been affected to the same extent by the restructuring of Ukrainian agriculture.

Similar to plant production, the first post-soviet years in Ukraine were marked by a decline in animal production (Figure 2). Cattle, swine, sheep and goats and poultry stocks showed a significant drop until the late 1990s. As the bars in the graph (right axis) show, poultry production recovered beginning in 2001. Numbers of swine and sheep and goats (left axis) stabilized 10-15 years ago.

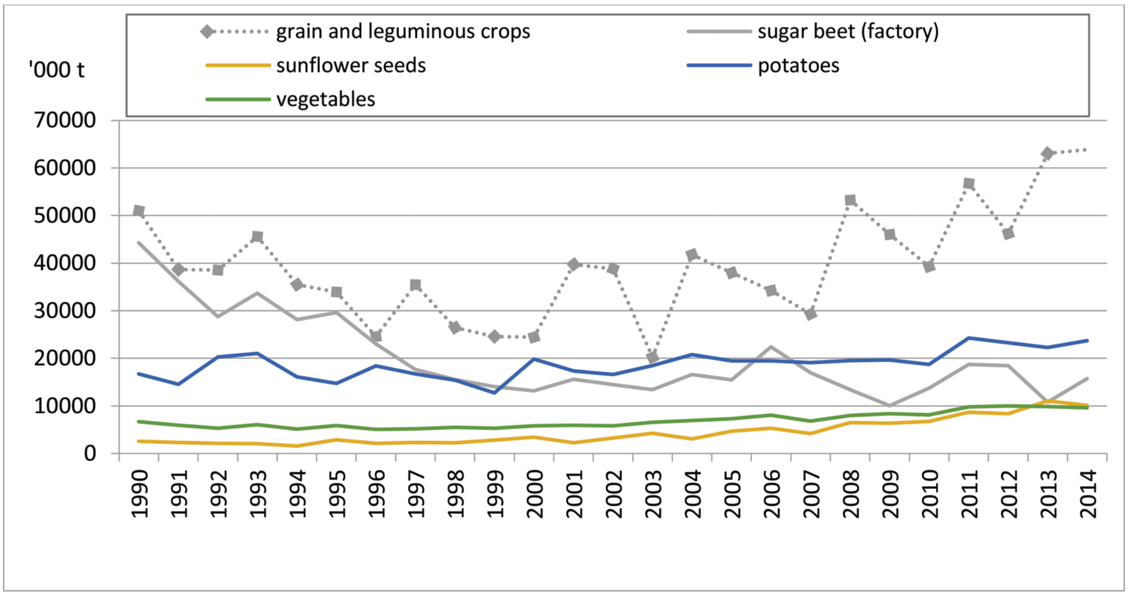

Figure 1: Development of arable production in Ukraine (1990-2014)
Source: UKRSTAT, 2014.

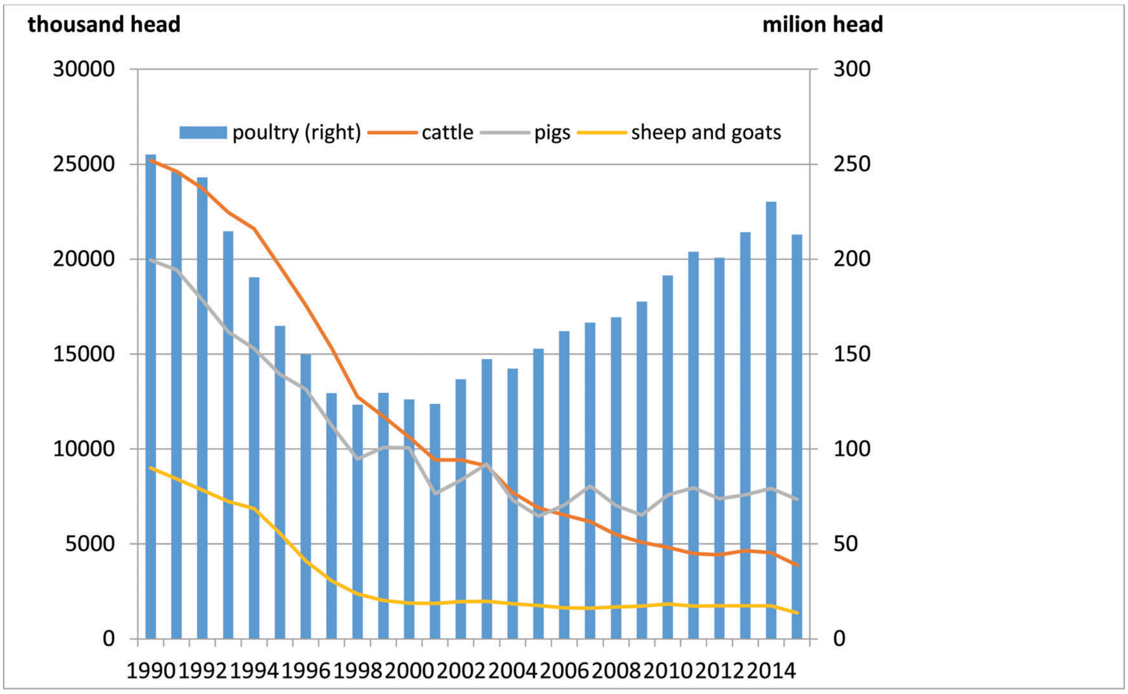

Figure 2: Development of animal production in Ukraine (1990-2014)
Source: UKRSTAT, 2014.

The continued decrease in cattle numbers was observed in many Central and Eastern European (CEE) countries and is mainly based on a drastic reduction of the dairy herd. The dairy sector in Ukraine still has not consolidated and restructured.

Farm structure in Ukraine

The official Ukrainian statistics distinguish between household and agricultural enterprises, of which private farms account for three quarters of the total (Table 1). State farms, agriholdings and independent agricultural enterprises represent the balance (UKRSTAT, various).

Private household production (''households'') played a considerable role during Soviet times, when households accounted for a major share of the production of meat, milk, eggs, fruits, vegetables and potatoes. Since 1991, their importance for these products has hardly decreased (Lapa *et al.*, 2010, Moroz 2013), and households have also gained importance in the production of arable crops such as grains and oilseeds. In 2014, households held a 44.7% share of gross agricultural production and farmed roughly 15.1% of Ukrainian agricultural land. Almost 99% of private households farm less than 10 ha (Lapa *et al.*, 2010). While household use plays an important role, they often also sell a portion of their production.

Linkages between households and commercial farms are manifold. Village dwellers often are part of the commercial farms' labour force, buy livestock feed from their employers or receive some of the feed for the households' animals as in-kind land rent (Koester and Striewe, 1999). In addition, empirical findings from Mamonova (2015) indicate large farming enterprises assist private households with fieldwork operations and social services.

Private agricultural enterprises and agriholdings are included in the category of non-state farms. Independent agricultural enterprises are commercial farm businesses with employed labour and, typically, employed management. This farm segment is very heterogeneous. It contains the successors of the former collective and state farms, which often are in dire economic straits. On the other hand, it also contains economically successful, restructured operations. Agricultural enterprises produced 55.3% of production in 2014, had an almost 60% share of crop production and a share of 49.5% of total agricultural land. According to Balmann *et al.* (2013), agriholdings account for a high share of the production of sunflowers, wheat, rapeseed, soybeans, corn, sugar beets, pork and poultry.

3. Competitive advantages and disadvantages of corporate farms in Ukraine

The development of agriholdings and large-scale farming operations that has been observed in many Eastern European countries was not expected by many Western European agricultural economists. Rather, the development of smaller family farms was anticipated (World Bank, 1992). Most studies explain the phenomenon with factors specific to transition economies.

A number of authors use economies of scale as part of their explanations for the development of agriholdings in Kasakstan, Russia and Ukraine (e.g., Zimmermann, 2004; Wandel, 2007; Demyanenko, 2008). However, the size of many agriholdings far exceeds the sizes at which relevant economies of scale are expected based on the experience in other countries.

Visser *et al.* (2012) suggests land speculation as a possible reason for the massive accumulation of agricultural land (''*land grabbing*'') by agriholdings in Russia. According to this explanation, investors buy agricultural land in the expectation of future appreciation in value.

The next group of explanations for the development of agriholdings refers to political economic factors. Gataulina *et al.* (2005) point out that the development of agriholdings in Russia was strongly supported by the authorities through the provision of credit, property or certain privileges. Another example is tax privileges (Hockmann *et al.*, 2005). In some Russian regions, the state even invested directly in agriholdings (Gataulina *et al.*, 2005). There also is evidence that in Russia, large agribusiness companies were actually pressured to invest in primary agriculture (Rylko and Jolly, 2005). Balmann *et al.* (2013) state that agriholdings can better adapt to existing deficits in the economic environment of Ukrainian agriculture.

Table 1: Farm structure in Ukraine

	Total	Agricultural enterprises				Households
		All	Portion that are state farms	Share that are non-state farms		
				All	Portion that are private farms	
Number of agricultural enterprises		52,543	228	12,887	39,428	4,136,800
Gross agricultural production in 2014 (in 2010 prices, %)	100.0	55.3	0.9	54.4	7.6	44.7
Gross crop production in 2014 (in 2010 prices, %)	100.0	59.4	1.0	58.4	10.0	40.6
Gross animal production in 2014 (in 2010 prices, %)	100.0	45.5	0.6	44.9	1.8	54.5
Agricultural land (thousand ha)*	41,511,7*	20,548,9	943,6	19,605,3	4,707,7	6,296,5
Arable land (thousand ha)*	32,531,1	19,293,4	780,7	18,512,7	4,543,2	5,424,7

*Difference between 'total' and 'ag. enterprises' + 'households' is 'other users', such as local communities, etc.
All statistical data providing information on the results of the year 2014 and later reflect the part of Ukraine's territory that is not occupied and annexed; i.e., data do not include Crimea and occupied parts of Donetsk and Lugansk regions.
Source: UKRSTAT, 2014.

Another reason to explain the prevalence of agriholdings is market failure. Strubenhoff (2011) found the market for capital to be particularly underdeveloped in Ukraine. Agriholdings were found to have considerably better development options than traditional farms because they have the means to establish international accounting and auditing systems that reduce lenders' risk. Further, they can access international capital markets (Strubenhoff, 2011).

A serious problem in Ukraine in the past has been the lack of contract enforceability and practically no security of private property rights (Thiel, 2002). Another important set of market-supporting institutions is the standardization of goods and services, as well as quality assurance and control systems. In this field, Ukraine has a particular disadvantage (Lapa *et al.*, 2010). The authors consider the system of quality and safety as one of the weakest points in Ukrainian agribusiness. Agriholdings therein are seen as a way to save transaction costs (Koester, 2003; Hockmann *et al.*, 2005). Vertical integration between supply and processing is the most important way to decrease such transaction costs.

Another explanation offered for agriholding development assumes that they aim at gaining and increasing market power (Khanna and Yafeh, 2007, FAO, 2009). Some authors explain the persistence of large farms via the long history of large-scale farming in Russia and Ukraine and a positive attitude toward this farm type (Mamonova, 2015, Koester and Petrick, 2010, Hockmann *et al.*, 2005).

Concerning the competitive advantages and disadvantages of agriholdings compared with independent commercial farms, only a few scientific studies exist. An early study from Gorton and Davidova (2004) measuring the productivity and efficiency of corporate farms versus family farms in selected CEE countries, found no significant difference between those farm types.

One study about the profitability of six crops grown in agriholdings (>10,000 ha) and independent farms (<10,000 ha) is provided by Byerlee *et al.* (2012) using accounting data and estimates from the Ukrainian Agribusiness Club. For all crops except one, their figures indicate lower profitability of agriholdings – in three cases, almost by 50%. Using farm-level accounting data for the period 2008–2012, Balmann *et al.* (2013) found that agriholdings did not exhibit a significantly higher or lower efficiency than independent enterprises. The authors also found that efficiency of agriholdings increased over the years through more intensive practices.

Regarding future adaptations of the organizational forms, one group of authors reflected on the future of agriholdings. Rylko and Jolly (2005) as well as Rylko *et al.* (2008) point out the managerial dilemmas faced by agriholdings in Russia: The management typically has a strong top-down approach, as is customary in the industries from which the decision makers come. This approach conflicts with the requirements of arable farming, where short-term expert decisions are needed at individual operations. However, delegating management responsibility to the local level can quickly lead to losses from local mismanagement and abuse of freedoms.

The results related to the competitiveness of agriholdings in comparison with independent farms are quite limited and inconclusive. More research is needed that compares these organizational forms. So far, no empirical approaches that involved farm business decision makers have been used.

4. Methodology and data

Several determinants influencing the competitiveness of agricultural enterprises have been analysed in the past (Schaper and Theuvsen, 2011). No single definition or technique defines competitiveness in agriculture. A number of studies in agricultural economics explain the competitiveness of farms taking into account cost of production and framework conditions using survey or accounting data (Schaper and Theuvsen, 2011).

For the competitiveness of Canadian agribusiness, Martin *et al.* (1991) defined competitiveness as the sustained ability to profitably gain and maintain market share. In this article, competitiveness shall be defined as a farming enterprise's sustained ability to profitably expand and maintain its share in cultivated farmland area. Therefore, a suitable quantitative indicator of competitiveness is the return to land that a business generates. This indicator reflects the maximum land cost a business could afford in the longer run – either in the form of land rents or the opportunity costs of owned land – without resulting in economic losses.

Due to a lack of detailed and reliable farm-level data in Ukraine, exploring competitive advantages and disadvantages of agriholdings is a challenge. Therefore, 'typical farms' have been established following the typical farm approach described by Zimmer and Deblitz (2005), and similar to the concept of representative farms (Sharples, 1969; Nuthall, 2011). These have been adapted to Ukrainian framework conditions. The typical farm approach utilizes the expert knowledge of farm decision makers and farm advisors to establish, validate, and explain typical farms – farm-level datasets that have a case-study character. A typical farm represents a stringently defined sub-group of a total farm population (Nuthall, 2011). It is defined by attributes such as size, combination of enterprises, production systems, management performance, yield level, input intensity, etc. (Zimmer and Deblitz, 2005).

Three steps were undertaken to establish the typical farms and determine their economic advantages and disadvantages:

(1) In the first round, a series of face-to-face interviews were held, in which farm data and qualitative assessments were collected. These interviews were conducted with agriholding and independent farm managers. Additionally, agribusiness representatives and external scientists/analysts were included in this round to contribute information where the other participants lack knowledge.
(2) In the second round, two separate focus-group discussions were held – one with agriholding managers and one with independent farm managers. In this round, the typical farms and the participants' qualitative assessments about competitive advantages and disadvantages of both organizational forms were validated and completed.
(3) In the third round, a single focus group with both the independent farms and agriholding managers was held. The qualitative and quantitative results were further validated and future adaptations were considered. The scope of the analysis is arable farming only.

Research region and case-study design

The research region selected to conduct face-to-face interviews and focus-group discussion was selected according to the following criteria: All typical farms are in the same region; the region is homogeneous regarding the importance of arable production, the prevailing production systems and the existence of both organizational forms. Thus, results are not representative for the whole country, but have more of a case-study character. Nevertheless, the approach allows exploration of major competitive differences between the two organizational forms.

The region selected comprises the entire Oblast Vinnitsa and adjacent parts of Cherkasy and Kiev. The oblast is the term for the 24 administrative units in Ukraine, similar to a region. This region is one of the core regions of arable production in Ukraine. In 2010, agriholdings accounted for 37.5% of arable land use in Vinnitsa, 17.5% in Kiev, and 28.5% in Cherkasy (Lapa *et al.* 2010). While there are no statistics on the share of restructured independent farms in the area, the panel participants reported that the region is one where structural change has been going on longer than in other parts of Ukraine and therefore the share of progressive farms is relatively high. A likely reason is that the yield potential in the area is high compared with other regions, leading investors to arrive early in the region. It has fertile and productive Chernozem soils. Chernozem soils, or black earth soils, are typically found in the long-grass steppe regions of the world.

Managers of four independent farms and just one agriholding participated in the panel process. Four typical farms were established: One agriholding with 2,000 ha and one with 10,000 ha; one independent farm with 2,000 ha and one with 10,000 ha. The unit of reference in the analysis is the single farm.

The agriholding operations have overhead costs from the central organisation allocated to them. The smaller typical farms reflect the farm size that accounts for most of the arable land in Ukraine. The larger ones, on the other hand, reflect a farm size at which the panel participants considered most economies of scale at the farm level to be fully utilized.

The typical independent farms represent restructured independent farms (as opposed to small family farms or non-restructured collective farms). The panel process revealed the managers of the independent farms represented top performers among their peers. This is important to keep in mind when interpreting the results.

5. Results

Differences in key economic cost and return elements

During the three rounds of face-to-face interviews and focus groups, all participants (including the agribusiness representatives and external experts) were asked what they consider to be the most important competitive advantages and disadvantages of agriholdings and independent farms. For agriholdings, competitive advantages were stated to include better and cheaper access to capital. Both organizational forms have access to bank loans in Ukraine's national currency, supplier financing for variable inputs and machinery financing. Agriholdings also have access to considerably cheaper bank loans in foreign currency and loans by the European Bank for Reconstruction and Development (EBRD). Further, they can access equity capital via international private equity and/or stock market capital. While smaller independent farms cannot access these cheaper sources of

Map 1: Oblasts in Ukraine
Source: Author illustration.

capital, large independent farms, in some cases, can establish the conditions to access foreign currency loans or even EBRD loans. However, even they usually cannot access international private equity or stock market capital. Agriholdings also receive more favorable terms in input purchases and output sales. This primarily stems from negotiating power thanks to the large volumes they turn over.

Competitive disadvantages of agriholdings were said to include lower efficiency than independent farms. Their yields are lower than those of the independent farms, by more than would be warranted by their less intensive system. The following reasons for this were given by the focus group participants: (a) The typical agriholding farms currently have less capable farm managers than the participating top-performing independent farm managers. (b) Agriholdings have longer decision chains and more standardized processes, which makes them less flexible. (c) The participating agriholding has grown extremely rapidly over the past year (which is typical in this organisational form). Finally, (d) it is more challenging to control theft, fraud and corruption at agriholdings than at independent farms. Another competitive disadvantage of agriholdings is the costs incurred by their central organization, which appear as overhead costs.

In addition to these competitive advantages and disadvantages, a number of factors were indicated but not conclusively confirmed:

- Although both organizational forms need to be locally politically connected, agriholdings derive competitive advantages from political clout, especially at the regional and national levels.
- Agriholdings can suppress competition in the land market and thereby have better and cheaper access to land than independent farms.
- Highly capable farm managers have a preference to work at independent farms, because they have more decision-making authority and fewer bureaucratic constraints.

The competitive advantages and disadvantages of agriholdings were quantified during the process. Table 2 illustrates key differences in cost and return components between the two organizational forms.

Economic performance of the typical farms

The typical-farm models established in the three-round focus-group process allowed calculation of returns, cost of production and the return to land of the typical farms as indicators for economic competitiveness.

As can be seen in Figure 3, the total costs of both typical independent farms are higher than those of both typical agriholding farms. Within the organizational forms, the larger operations have lower costs per hectare than the smaller ones. The total revenues of the typical independent farms are higher than those of the typical agriholding farms, thanks to their higher yields, with the large typical independent farm having slightly higher revenue than its smaller peer thanks to its output price advantage of 5 USD/t. The output price advantage of the typical agriholding farms is not sufficient to compensate for their lower yields.

The graph differentiates among cash cost, depreciation and opportunity cost. This provides information on the endurance of the farms, especially in times of crises. A high share of opportunity costs indicates stability, as an owner can temporarily (or even permanently) decide to forego (part of) the remuneration for his own factors of production without liquidity problems. The small independent farm has the highest opportunity costs because it has the highest equity ratio. In some cases, such smaller independent farms also have owner-managers. If this is the case, the remuneration of the farm manager (45 USD/ha), which currently is included in cash costs, becomes part of opportunity cost instead. This also may be the case at larger independent farms. In our example large independent farm, this cost factor amounts to 25 USD/ha.

Generally, opportunity cost is the calculated cost for all owned factors of production – namely, capital, labour/management, and land. However, the typical farms all rent their land and therefore have no corresponding opportunity cost. Further, the calculations with the typical farms were based on employed labour and management only, and therefore also have no opportunity cost for those factors of production. Hence, opportunity costs only for equity capital appear in the calculations.

Table 2: Key components for cost and return differences between agriholdings and independent farms

	Typical farms	Difference in cost or return component
Price advantage, machinery	10F vs. 2F	-5%
	AH vs. 2F	-15%
Price advantage, pesticides	10F vs. 2F	-3%
	AH vs. 2F	-10%
Price advantage, fertilizer	10F vs. 2F	0%
	AH vs. 2F	-5%
Price advantage, seeds	10F vs. 2F	-2%
	AH vs. 2F	-7%
Price advantage, outputs	10F vs. 2F	+5 USD/t
	AH vs. 2F	+10 USD/t
Yield disadvantage	AH vs. FA	-24%
Agriholding overhead costs	2H	+35 USD/ha
	10H	+25 USD/ha
Land cost	FA	62-65 USD/ha
	AH	62-65 USD/ha

Note: "2F" = 2,000 ha typical independent farm, "10F" = 10,000 ha typical independent farm, "2H"= 2,000 ha agriholding farms, "10H" = 10,000 ha agriholding farms, "AH"= typical agriholding farms, "FA" = typical independent farms. Yield disadvantage is average over all crops. Where ranges are shown, the figures differ between the small and large farms within the respective organizational form.
Source: Author's data.

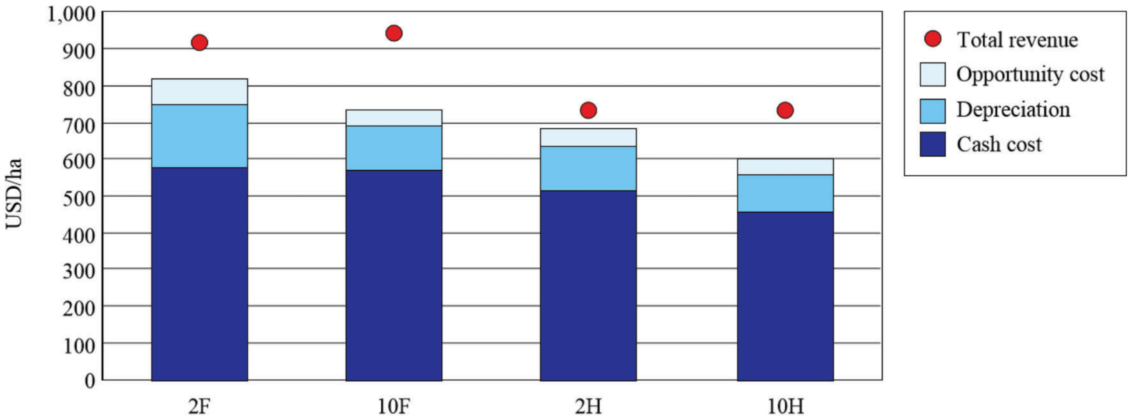

Figure 3: Total costs and revenue of the typical farms (average over all crops, USD/ha)
Note: "2F" = 2,000 ha typical independent farm, "10F" = 10,000 ha typical independent farm, "2H" = 2,000 ha typical agriholding farm, "10H" = 10,000 ha typical agriholding farm.
Source: Own illustration.

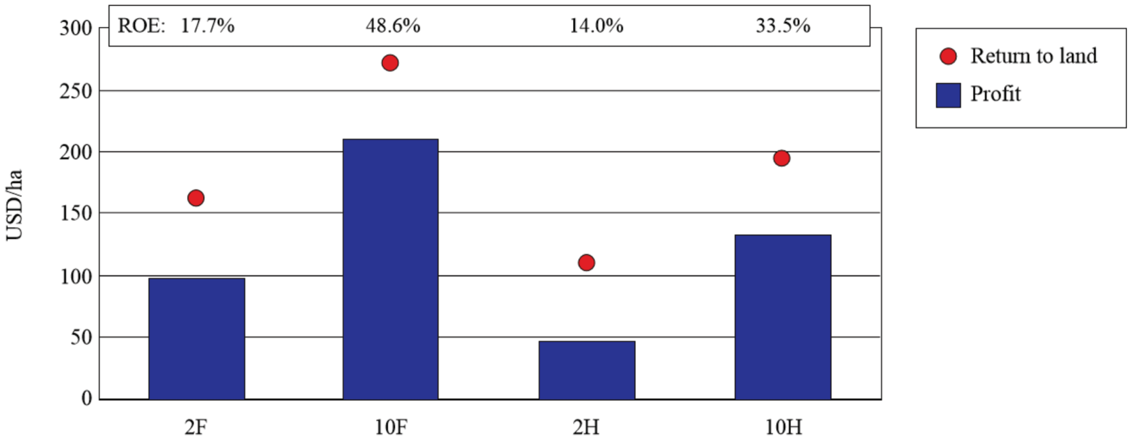

Figure 4: Return to land (USD/ha), profit (USD/ha) of the typical farms
Note: "2F" = 2,000 ha typical independent farm, "10F" = 10,000 ha typical independent farm, "2H" = 2,000 ha typical agriholding farm "10H" = 10,000 ha typical agriholding farm.
Source: Own illustration.

Figure 4 shows the economic performance of the typical farms. The key quantitative indicator of competitiveness in arable farming is return to land. As can be seen, this indicator is highest at the large independent farm; the second highest is achieved by the large agriholding farm. The 2,000 hectare farms achieve lower returns to land than the larger typical farms. The typical independent farm has again a higher return to land than the typical agriholding farm. Hence, the size of the operations has a greater impact on their return to land than the organizational form. The profits per hectare of the typical farms also are shown. They demonstrate the same ranking, at a lower level, as profit is return to land less land cost.

Further, the returns on equity of the typical farms are provided in text at the top of the graph. Their ranking is the same as the profit ranking, although factors other than profit play a role in this measurement – namely, the different capital structures and debt interest rates of the typical farms. The large independent farm not only has the highest profitability, it also has the highest debt ratio in its long-term capital. This provides leverage that increases the return on equity.

Overall, it can be stated that arable farming in Ukraine has been a very profitable investment for the analysed farm populations in the 2008-10 period, especially for larger farms within both organizational forms.

Future adaptations of agriholdings and independent farms

In the third round of focus group discussions, likely future adaptations of both organizational forms to maintain and increase their competitiveness were studied qualitatively. The following strategies of agriholdings were obtained by the participants. Consolidating the business by increasing the size of individual operations; taking unprofitable land or whole operations out of production; focus the umbrella organisation on its core functions and de-centralize management. This includes increasing the payment and incentivization of farm managers and taking measures to train or, if unsuccessful, replace them. As a result, a reduction in overhead costs and higher efficiency, especially at the farm level, is expected. Finally, it was also pointed out that agriholdings might take complexity out of their businesses, thereby reducing the management requirement. This could be done by simplifying crop rotations, as well as using larger machines and fewer workers.

In the case of independent farms, the following strategies were pointed out: Independent farms might found cooperatives in the future to fulfill certain tasks – especially purchases and sales – which the central organization fulfills at an agriholding. They also might consider diversification into specialty crops (such as vegetables) or livestock production as a growth alternative of choice if expanding their arable land becomes more difficult because of high land prices or difficulty in competing for land.

6. Conclusions

This article explores competitive advantages and disadvantages of agriholdings compared with independent farms. The analysis is based on information and typical farm data collected in expert interviews and focus groups with agriholdings and independent farm managers.

Given the fact that in countries such as Ukraine there is basically no official and reliable data on farm economics available, the typical farm approach is the only viable option unless there is a huge budget available to do a broader sampling.

The typical independent farms in this analysis generate higher return to land than their agriholding counterparts of the same size. This indicates that agriholdings will face economic pressure when increasing competition for land raises land costs in the future. On the other hand, the typical agriholding farms have more potential to improve their efficiency than the already highly optimized typical independent farms. Further, they can achieve the same return to land without entirely reaching the independent farms' efficiency thanks to their other competitive advantages (purchases, sales, etc.). Therefore, it seems possible the economic gap between the organizational forms may close in the future. Smaller independent farms, in particular, are in a difficult situation when the competition in the land market increases, as the return to land of large agriholding and independent farms is higher. While agriholdings have the liquidity to increase the size of their small operations, small independent farms are limited in their ability to grow, especially due to restrictions to access capital.

The statements regarding likely future adaptations permit the conclusion that there may be a convergence of the two organizational forms in the future, with agriholdings strengthening their farm-level management and focusing their central organisation on their key functions, with independent farms co-operating in purchases and sales. This might even go so far that franchise-like setups develop – in this scenario, an agriholding center cooperates with largely independent entrepreneurs who manage their farming operations.

The results of the analysis, in principle, are valid only for Ukraine. However, the more similar the conditions in a country, the more likely it is that results can be transferred. A high degree of transferability tentatively can be concluded for Russia and Kazakhstan, as the economic and political conditions are largely comparable to those in Ukraine. In the interpretation of all results, it is important to keep in mind that the derived typical farms have a case-study character, which limits their degree of representativeness for the farm population as a whole. Further, as the results are based on the knowledge and data of the participants, certain factors may have been overlooked and others overemphasized.

About the authors

Simon Walther has a PhD from the University of Hohenheim. Born and raised on a farm in Bavaria/ Germany, his scientific work on agriculture in the Former Soviet Union began with his Master Thesis in 2006 on farm mechanization in Russia. From 2009 to 2012, he worked at agri benchmark headquarters, developing the network in Ukraine, Russia and Kazakhstan. Since 2013, he has worked for John Deere in the company's Strategic Marketing department for the European, African, Middle Eastern region. As Market Planner for the Commonwealth of Independent States, his primary professional focus has been the agriculture of the former Soviet countries. In 2016, he took over the arable farm from his parents in Bavaria, Germany.

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Acknowledgement

The authors would like to thank the farm managers and experts who participated in the interviews and focus groups for their cooperation and openness. Many thanks further go to Jürgen Zeddies, Folkhard Isermeyer and Yelto Zimmer for their supervision of the research and dissertation, Thomas de Witte for a lot of valuable feedback, as well as to Annerose Gillner and Helga Prüsse for their great technical support. The German Agricultural Society (DLG) provided financial support, which was highly appreciated. Finally, we would like to thank the anonymous reviewers for the time dedicated to this article.

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CASE STUDY

DOI: 10.5836/ijam/2017-06-71

Peer recognition of outstanding achievement towards UK agricultural progress

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ABSTRACT

This Paper traces the history since its 1970 launch, operation and impacts of the scheme for peer recognition of outstanding contributions to agricultural progress within the UK. The Council for Awards (CARAS) is sponsored by the four national Royal Agricultural Societies (RAS) of England, Northern Ireland, Scotland and Wales. CARAS awards Associateships (ARAgS) and Fellowships (FRAgS), under a Constitution reframed in 1984, revised in 1990. Potential Associates are invited to apply by National Panels in the four nations and required to provide a submission of their work to date, with two existing Fellows (FRAgS) to provide sponsor letters. Subject to satisfactory submission and sponsors' letters, two Assessors are appointed from among existing Fellows to meet each candidate. The Assessors' joint Report is then considered by a Moderator's Panel of CARAS, which approves Associateships (ARAgS). Advancements to Fellowship (FRAgS) are conditional upon further outstanding contributions to UK agricultural progress based on citations to CARAS. The Paper reviews diverse benefits hypothesised for those thus recognised and some collective activities of members. It seeks to evaluate the impact of these awards in motivating excellence for UK agricultural progress and public benefit by analysis of responses from almost 600 recipients of the awards.

KEYWORDS: agriculture; rural; progress; peer recognition; awards; management impacts

1. Introduction

Agriculture is a worthy profession, blending as it does the arts and sciences, wrestling with the appropriate management of everything from the weather to soils, crops and livestock. Jonathan Swift, in his early eighteenth century classic *Gulliver's Travels* famously wrote that 'whoever could make two ears of corn or two blades of grass to grow upon a spot where only one grew before would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together!' A similar sentiment was expressed by George Washington who thought 'no more real service can be rendered than by improving agriculture'. Cicero (104-43 BC) was of the opinion that 'of all the occupations by which gain is secured, none is better than agriculture, none more profitable, none more delightful, none more becoming to a free man' (*De Officiis* 1.51). Agriculture has an even older pedigree in the Fertile Crescent of the Middle East over 5,000 years ago. What of the calibre, motivations, standards and encouragement of those who work in agriculture now? Space does not permit an exploration of the extensive literature on motivational theory, such as pioneered by McClelland (1953), nor of more recent emphases on the psychology of personality and achievement (such as Cervone *et al*, 2006). However, it is the contention of Florida (2002) that peer recognition can promote creativity and effectiveness in a variety of contexts. Does such extrinsic motivation apply in agriculture and what of its changing leadership patterns in the UK (Alliston & Gonzalez-Diaz, 2005)? This Paper asks whether due recognition of distinguished personal achievement in agriculture - by one's outstanding peers (contemporaries) who also work within agriculture - can help to motivate improved agricultural management for sustainable livelihoods and public benefit as may be claimed (see Table 1 and Wibberley, 2007, 2016)? It attempts to answer these hypotheses by the description of a UK scheme for such recognition with feedback from a large sample (n = 593), 49% of those so recognised who are currently living. The approval of CARAS Council to conduct and to fund this postal survey of all its awardees is acknowledged with gratitude by the authors; sincere thanks are due to our wives for their support and to all who responded to the survey.

2. History of the UK scheme for recognition by peers

The four sponsoring Royal Agricultural Societies (RAS) are now: The Royal Highland & Agricultural Society

Original submitted April 2017; accepted May 2017.
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Table 1: What outcomes might follow public recognition of agriculturalists by their peers?

1. Consumers gaining quality assurance of the producer not just the product (though obviously linked) transferable between employers and/or clients for produce and outputs.
2. Recruitment of young and new entrants through a recognised, practically relevant route.
3. Fellowship channel for existing leading practitioners to share systematic lifelong learning.
4. Solidarity of competence with others engaged in varied aspects of agriculture.
5. Credibility and coherence of experience and skills to approach policy-makers and public.
6. Boosted morale of those engaged in our most fundamentally important economic activity.
7. Being part of a voluntary scheme to shape the future rather than have it shaped for us.

Figure 1: RASE / RHASS / RUAS / RWAS = sponsoring Royal Agricultural Societies of CARAS Scheme in UK

of Scotland (RHASS – founded in 1784), The Royal Agricultural Society of England (RASE – founded in 1838), The Royal Ulster Agricultural Society (RUAS – founded in 1854) and The Royal Welsh Agricultural Society (RWAS Ltd. – founded in 1904). CARAS (The Council for Awards of Royal Agricultural Societies) acts on behalf of these four national Royal Agricultural Societies. Throughout this Paper when 'CARAS' is used as shorthand it must be remembered that it is 'The Fellowship of Royal Agricultural Societies administered by CARAS' Figure 1.

In 1969, discussions took place at the instigation of Everard Hosking of the RASE who had envisioned and catalysed the setting up of a working party and invited collaboration from the RHASS and the RWAS to establish a Fellowship scheme for those making significant contributions to the benefit of farming. Alongside practising farmers it would include those in the professions and ancillary industries (Soper, 1994). The three RAS agreed to set up a Council of Fellows of Royal Agricultural Societies to make awards in two grades – a senior award of Fellowship and a supporting award of Associateship. The scheme was launched in 1970 with an initial award of some 70 Fellowships to a group of distinguished agriculturalists from the three countries, with Eric Tasker as Secretary under the chairmanship of Everard Hosking. He was succeeded as Chairman by Sir Harold Sanders, who was followed by Robert F.Gregor MBE of the RHASS (Gregor, 2010). Council meetings were held in London, first at the RASE in Belgrave Square, then at the NFU in Knightsbridge and subsequently at the Farmers' Club in Whitehall Court where many of them continue to this day. Associateship was initially to be awarded to those who submitted a 10,000 word dissertation demonstrating significant contribution to practical agricultural progress, to be examined by two Fellows. However, such lengthy writing asked too much of busy farmers and a crisis was reached in 1982 when the Council rejected reforms proposed by the RASE, which withdrew its support in 1983 as a consequence (Soper, 1994). There were also some within the Council at that time who wanted it to assume a political role within agriculture, and at the same time quickly to enlarge the Fellowship by direct election of a considerable number of Fellows. This factor also led to the crisis (Gregor, 2010). At that point, the RUAS was invited to join the remaining two RAS and the UK Council for Awards of Royal Agricultural Societies (CARAS) was established in 1984, with its present Constitution from 1990, and gained UK Registered Charity status (No.327030). From 1983/4, it was under the chairmanship of Sir Meuric Rees CBE of Wales, with John Wigley OBE as Secretary and Professor Jim S. Hall CBE as Moderator. It followed on from that begun in 1970 as a Council of Fellows of the three national Royal Agricultural Societies of the UK, as a 'grandparent generation' of those widely acknowledged as having made contributions of real distinction to agricultural progress within the UK, who were designated as foundation Fellows. English members kept their links going after RASE withdrawal – including Ian Gibb OBE who served as CARAS Secretary from 1989-2000. RASE rejoined the scheme in 1991 and provided the next Moderator, Dr Tony Harris CBE who served until 2009.

The objective is to recognise, through this Awards scheme, distinguished achievement in agriculture and related land-based industries, though only with capacity to take account of and evaluate contributions made within the UK. Thus CARAS exists to recognise outstanding contributions already made to agricultural/rural progress but does it not also stimulate and encourage yet further excellence of contributions from its recognised members? The Awards embrace not only practical farming and the development of new husbandry practices, but also research, technology, economics, education, farming care, communication and administration. A Fellowship (FRAgS) or Associateship (ARAgS) is a recognition of outstanding contribution by an individual to the understanding, efficiency and well-being of agriculture. To date, some 1,500 individuals have been so recognised and there are currently some 870 Fellows and some 340 Associates. Council is aware that there will be many other candidates worthy of consideration by meeting the high standards required for an award. It seeks constantly to encourage existing Fellows to nominate such people to the National Panel of the candidate's nation of UK residence for them to consider and invite to apply.

3. Operation of the CARAS scheme in the UK

Administration

The scheme is administered by the Council for Awards, which consists of representatives of the participating Royal Agricultural Societies, members elected by the Fellows, ex-officio and co-opted members. The Council is supported by a National Panel in each of the four nations of the UK. Candidates for awards are initially invited by National Panels before recommendation to the Council (Table 2).

Associateship (ARAgS) is a recognition of meritorious contribution to the agricultural and land-based industries of the UK and is awarded to those who can demonstrate the required high level of achievement. Candidates do not apply but are invited to do so by Panels appointed within each of the four UK nations, nominating two existing Fellows as sponsors to vouch for their outstanding work.

Fellowship (FRAgS) is the senior Award of the Council. Associates may be considered for advancement to Fellowship if they can demonstrate a continuing significant contribution to agricultural and rural progress in the UK, although advancement is by no means automatic. Occasionally, the Council may award a Fellowship directly for exceptional achievement.

Holders of the Awards of ARAgS and FRAgS cover a wide spectrum. The Awards reward personal achievement in a professional capacity and recipients are frequently individuals of influence within Agriculture. They range from practical farmers to academics, company directors, media practitioners, administrators, advisors, consultants and those concerned with the well-being of farming and rural communities.

4. Expected privileges and benefits of fellowship and associateship

Members are identified with others who have demonstrated excellence and achievement thus comprising a distinctive group with much to contribute to the future development of UK agriculture, its associated industries and to wider rural progress for public benefit. National Panels arrange meetings and visits to discuss and exchange ideas. Social events provide an opportunity to meet with other Fellows and Associates. Newsletters and Reports on conferences and seminars are circulated regularly. Members of one of the sponsoring Royal Agricultural Societies can enjoy privileges of membership of the other participating Societies on application and at its discretion. A Fellowship or Associateship of Royal Agricultural Societies is a prestigious honour – a recognition of outstanding contribution to the understanding, efficiency and well-being of UK agriculture (Table 3).

5. Methodology and results of membership survey: impacts of recognition

A simple, one side of A4 questionnaire was sent out in January 2017 to all Fellows and Associates of Royal Agricultural Societies in the UK (just over 1200), with a stamped addressed envelope for ease of reply. Members were given over three weeks to respond. Many of the

Table 2: Entry Procedure of CARAS Scheme in the UK

1. Candidates when invited by the National Panel of the UK nation where they live should submit the application form together with an outline of their contributions to agricultural and rural progress. The form and entry fee should be forwarded to the Hon Secretary.
2. Candidates must be sponsored by two Fellows (holders of FRAgS).
3. Applications are subject to approval of a National Panel prior to submission to Council.
4. Two Assessors appointed by Council will interview the candidate to discuss the farming system, practice, project or personal contribution upon which the submission is based.
5. The Assessors will then prepare a Report on the interview for the Council.
6. On consideration of the Assessors' Report by the Moderator's Panel of the Council, a positive outcome will result in the award of Associateship (ARAgS).
7. Certificates are presented at appropriate events of participating Royal Agricultural Societies.

Table 3: Some intended Benefits of CARAS membership

1. **Recognition** of one's outstanding contributions to agricultural/rural progress;
2. **Fellowship** with others who have made similarly important practical contributions;
3. **Database:** Receipt of Annual Bulletin listing all members - over 1200 now - and detailing new members and those advanced to Fellowship, with overviews of their contributions;
4. **New members:** Ability to propose and seek out potential new members thus championing the cause of agricultural progress, which depends on a continual flow of creative people;
5. **Networking** with others to further the cause of agri-rural progress via influencing thinking, research and policy priorities, encouraging and highlighting practical innovations in agricultural science, technology, production, management, marketing and care in agriculture;
6. **Invitations** to Shows and other events - field trips and a February conference in the case of the Scottish and Welsh Panels - but members are also welcome to various events in the other nations;
7. **Expert Panels:** Members may be invited to join panels – or catalyse them - on specific issues related to their expertise;
8. **Service within CARAS:** Fellows may write sponsorship letters for new candidates, and some may be invited to act as Assessors, or to serve on their National Panel, or on Council;
9. **Publications:** Members are circulated twice yearly with the Bulletin in March and the July Newsletter, and by their National Panels during each year;
10. **Collectively**, members of the Fellowship across the UK act as independent custodians of the cause of agricultural and rural progress, bringing together those from diverse sectors - farming, research, government, commercial, communication - in all four nations of the UK.

answers were harvested through the 5-point Likert Scale tick box, plus limited written comment. Additionally – and 'killing two birds with one stone'! – members were invited to supply on the same reply form a 50-word profile of themselves to insert on the CARAS website. Invitations to do so hitherto via requests in our Newsletters and Annual Bulletin had only elicited a 9% return. The survey form is presented in Appendix 1. A 49% response rate was achieved by the end of four weeks. Of those, some 85% provided a website profile; some specifically declined to choose giving an entry. Associates (mean age 61.5) were marginally more inclined to do so than Fellows (mean age 68.7) – see Table 4.

Responses were via coded SAEs provided in order to give eight groups on receipt: England Fellows (EF), Northern Ireland Fellows (NIF), Scotland Fellows (SF), Wales Fellows (WF) with four groups for Associates – viz. EA, NIA, SA and WA.

Analysis of opinions of respondents provided the results summarised in Table 5. Assigning numbers to the Likert Scale responses from 5 = 'Strongly Agree' to 1 = 'Strongly Disagree', factors were calculated for each choice and an aggregate expressed for the eight categories (four nations of Associates and four of Fellows). These factors indicate the strength of opinion in each case.

Additionally, the percentage who either agreed or strongly agreed for each opinion requested were calculated and are reported in Table 6 and detailed in Appendix 2. There is a notable level of agreement on all questions between the eight groupings of Fellows and of Associates but some significant differentials, which will need pondering by National Panels later. Some interpreted questions like P 'CARAS urges me to contribute more to life' in terms of it not being the key motivator or else being one of many. In all cases, the aspect of enjoyment of their membership rated consistently highly.

Questions were then grouped into their hidden categories and analysed accordingly, as shown in Table 7. These categories were inspirational (motivational) factors, consequential outcome factors, cohesive (mutuality)

Table 4: Numbers and Age Profile of Associates and Fellows responding by Nation

GROUP	n	%	Av.Age (Years)	Age range
England Fellows EF	204	56	69	47-94
N. Ireland Fellows NIF	37	46	65	49-81
Scotland Fellows SF	98	46	71	45-93
Wales Fellows WF	111	52	70	46-96
England Associates EA	74	47	63	43-84
N. Ireland Associates NIA	15	49	64	49-81
Scotland Associates SA	30	39	59	43-82
Wales Associates WA	24	30	60	45-81

Table 5: Overall Strength of Responses of Fellows and Associates in the four nations

STRENGTH OF RESPONSE* **n** =	**204**	**37**	**98**	**111**	**74**	**15**	**30**	**24**
% Response	**56**	**46**	**46**	**52**	**47**	**49**	**39**	**30**
Topics on which your opinion is sought**:	**EF**	**NIF**	**SF**	**WF**	**EA**	**NIA**	**SA**	**WA**
A. Possible CARAS recognition inspired me	3.8	3.8	3.7	4.0	3.6	3.6	3.7	4.3
B. My CARAS recognition encourages me still	4.2	4.2	4.0	4.2	3.9	4.0	4.2	4.5
C. CARAS motivates me to collaborate with others	3.7	4.2	3.7	3.9	3.5	3.5	3.7	4.3
D. CARAS motivates me to promote Agriculture plus	3.9	4.2	3.8	4.1	3.6	3.8	4.0	4.3
E. CARAS scheme is for ultimate Public good	4.1	4.3	3.8	4.0	3.7	4.1	3.8	4.1
F. Advancing A to FRAgS needs far more extra output	3.5	3.8	3.4	3.9	3.5	3.6	3.0	3.6
G. CARAS must stick to its core **Awarding** role	4.0	3.9	3.7	4.1	3.7	3.8	3.8	4.0
H. It's good CARAS recognises Agric.**Plus** other rural	4.0	4.2	4.1	4.2	4.1	4.1	4.3	4.2
I. CARAS motivates better work standards	3.7	3.8	3.7	3.9	3.7	3.8	3.9	3.7
J. CARAS fellowship is enjoyable	4.3	4.7	4.5	4.5	4.1	4.1	4.3	4.3
K. CARAS involvement stimulates creative thinking	4.0	4.5	4.1	4.1	4.0	3.7	3.9	4.2
L. CARAS involvement stimulates positive action	3.8	4.3	4.5	3.9	3.8	3.9	4.0	3.8
M. CARAS widens my Agric./Rural understanding	4.0	4.6	4.0	3.9	3.9	4.2	4.0	4.4
N. CARAS exposes me to other Agric. opinions	4.0	4.5	4.2	4.1	3.9	4.2	4.2	4.1
O. CARAS sharpens my resolve to learn more	3.6	4.2	3.7	3.9	3.6	4.1	4.0	4.2
P. CARAS urges me to contribute more to life	3.6	4.2	3.6	3.9	3.6	3.9	3.9	3.9
Q. CARAS standards are kept with rigour	3.8	4.2	3.8	3.7	3.9	3.9	3.9	4.1
R. CARAS policy to ***invite*** applicants is right	4.2	4.3	4.1	4.2	4.1	4.1	4.2	3.8
S. CARAS members' varied Agric.links are good	4.3	4.4	4.3	4.1	4.1	4.1	4.2	4.5
T. CARAS website is a welcome development	4.1	3.7	3.9	4.1	4.0	3.4	4.2	4.2
U. I intend to use CARAS website	3.8	3.9	3.8	3.9	3.9	3.6	4.1	4.2
V. CARAS March & July mailings are enough	3.9	3.8	3.8	3.9	3.9	3.3	3.8	3.7
W. CARAS should celebrate its Jubilee in 2020	4.3	4.6	4.1	4.3	4.3	3.8	4.3	4.5
X. Members should attend their National Panel events	3.6	4.2	3.9	4.1	3.6	4.2	3.7	3.9
Y. CARAS scheme is well understood by outsiders	2.1	2.3	2.2	2.4	2.2	2.0	2.5	2.4

*Using Likert Scale choices and multiplying the number of respondents to the question by 5,4,3,2,1 respectively (where 5 = strongly agree) which are then aggregated into a factor out of 5.0. Overall, there was a 49% response from all existing members via this SAE postal survey + website entry form (52% response from Fellows and 42% response from Associates). **Associates** = **A; Fellows** = **F**
****E, NI, S, W** = **England; N Ireland; Scotland; Wales.**

Table 6: Averaged Percentage Agreement among Respondent Fellows and Associates

AV.PERCENTAGES Agree + Strongly Agree	**n = 450**	**n =143**
***see Note below**	**Fellows**	**Associates**
Topics on which your opinion is sought:		
A. Possible CARAS recognition inspired me	73.7	72.2
B. My CARAS recognition encourages me still	85.5	90.7
C.CARAS motivates me to collaborate with others	69.7	71.0
D.CARAS motivates me to promote Agriculture plus	79.5	79.5
E.CARAS scheme is for ultimate Public good	81.2	74.0
F. Advancing A to FRAgS needs far more extra output	56.7	40.5
G.CARAS must stick to its core **Awarding** role	71.5	66.0
H. It's good CARAS recognises Agric. **Plus** other rural	83.0	86.7
I.CARAS motivates better work standards	64.2	73.5
J.CARAS fellowship is enjoyable	94.5	87.0
K.CARAS involvement stimulates creative thinking	84.0	82.0
L.CARAS involvement stimulates positive action	77.0	79.2
M.CARAS widens my Agric./Rural understanding	82.7	81.5
N.CARAS exposes me to other Agric. opinions	89.7	88.7
O.CARAS sharpens my resolve to learn more	69.7	79.5
P.CARAS urges me to contribute more to life	65.7	76.0
Q.CARAS standards are kept with rigour	72.7	75.2
R.CARAS policy to ***invite*** applicants is right	86.5	81.7
S.CARAS members' varied Agric. links are good	93.7	88.7
T.CARAS website is a welcome development	82.2	77.2
U.I intend to use CARAS website	69.7	76.0
V.CARAS March & July mailings are enough	77.5	68.7
W.CARAS should celebrate its Jubilee in 2020	90.5	89.0
X. Members should attend their National Panel events	76.2	63.5
Y. CARAS scheme is well understood by outsiders	6.7	4.7
% Providing Website entry	83.2	85.2

**Note:* Differentials between nations are for Panels to ponder and discuss later.

Table 7: Factor Categories from grouped responses

FACTOR CATEGORIES(with Questions)**	**EF**	**NIF**	**SF**	**WF**	**AV.F**	**EA**	**NIA**	**SA**	**WA**	**AV.A**
Inspirational (A, B, K, L)	3.95	4.20	4.07	4.05	**4.07**	3.82	3.80	3.95	4.20	**3.94**
Consequential (C, D, E, I)	3.85	4.12	3.75	3.97	**3.92**	3.62	3.80	3.85	4.10	**3.84**
Cohesive (J,S,W,X)	4.12	4.48	4.20	4.25	**4.26**	4.02	4.05	4.12	4.30	**4.12**
Educational (M, N, O, P)	3.80	4.37	3.87	3.95	**4.00**	3.75	4.10	4.02	4.15	**4.00**
Communications (T, U, V)	3.93	3.80	3.83	3.97	**3.88**	3.93	3.43	4.03	4.03	**3.85**
Policy (F, G, H, Q, R)	3.90	4.08	3.82	4.02	**3.95**	3.86	3.90	3.84	3.94	**3.88**
Public Understanding (Y)	2.10	2.30	2.20	2.40	**2.25**	2.20	2.00	2.50	2.40	**2.27**

***Note:* Associates = A; Fellows = F; and E, NI, S, W = England; N Ireland; Scotland; Wales.

factors, educational (both learning by members and inclination to share knowledge), communications (both existing publications and web potential), policy (of CARAS organisational procedures) and public understanding.

The 'public understanding' category - about understanding of the CARAS scheme by outsiders - was considered deficient by all groups i.e. the majority disagreed or strongly disagreed that the CARAS scheme is well understood by outsiders. Given that applicants are invited to apply – as consistently supported across all eight groupings – one might question how important it is for outsiders to know about the scheme. On the other hand, if its existence can inspire people in agriculture to aspire to contribute significantly enough to agricultural progress to be recognised by CARAS, then its existence and standards need to be better known. Many respondents commented specifically to that effect, also noting the importance of better understanding within agriculture and the public in general of what the standards mean once awarded. To this end, CARAS is now, and has been for some years, listed in *Whitaker's Almanack* among Charities and Societies. It is noteworthy that all other categories were rated highly positively by all eight groupings of Fellows and Associates in the four nations of the UK with the exception of Question F 'Advancement from Associate to Fellow needs far more extra output'. This statement proved ambiguous; some took it to mean 'ought to require far more extra effort' (on which opinion varied) while others seemed to take it retrospectively for either their own case or for other awardees, and some thought it had not required 'far more extra effort'. Perhaps it would have been better phrased 'Advancement from Associateship to Fellowship should require far more extra effort'? CARAS Council and the National Panels of each nation will need to digest and debate the findings and differentials between their respondents and respondents as a whole, on which comparisons and contrasts are precluded by time and space here. There was strong endorsement from this survey for the existing procedures and policies of CARAS, where results again merit proper, more detailed reflection.

The strongest trends emerging are shown in Figure 2 where Fellows showed somewhat higher appreciation than Associates of inspirational, consequential, cohesive

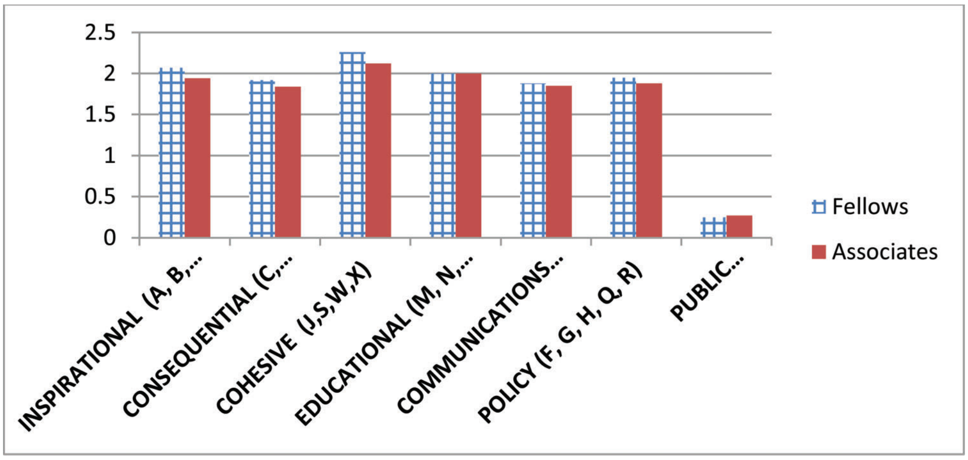

Figure 2: Relative Strength of Grouped Responses: Fellows (n= 450) and Associates (n =143) Website: http://www.royalagriculturalsocieties.org/

and policy aspects. There was no difference in the appreciation of educational and communications matters between Associates and Fellows, and both groups clearly thought the CARAS scheme not well understood by outsiders.

The questionnaire also invited members to comment on how the CARAS scheme would best be improved, and also on what if anything they would like to be added to its role (noting that it is **not** a lobbying group). Only some 22% commented – and constructively so - on potential improvements, while around 17% of the respondents chose to comment on the role of CARAS, several of those urging it to concentrate on its core Constitutional role of recognising excellence and making awards accordingly. A full digest of responses has been compiled for fuller analysis and consideration by the Council of CARAS and its National Panels in each of the four nations. However, here is presented an overview of the main issues raised about the improvement and role of CARAS. These concern publicity so that what CARAS Fellows and Associates have to offer is better known to promote agriculture for public benefit with independent, objective and balanced analysis. There is great concern to encourage the next generation into agriculture, by offering mentoring and exploring other ways of encouraging them, including in schools, colleges and universities. There is a desire to monitor research and development priorities, to share in focus groups on specific topics of the moment, and especially to feed into the discussion and policy-making around Brexit. There are several members who believe that CARAS should engage again with the exploration of professional recognition and possible ultimate Chartered Status for Agriculturalists. This would mean liaising with our colleagues in the Institute of Agricultural Management (IAgrM) whom we encouraged to pursue, as they have done, the P.Ag (Professional Agriculturalist) scheme after CARAS catalysed a comprehensive exploration of professional recognition in 2007 (Wibberley, 2007). The reason that Council decided then that its catalytic role was accomplished and to hand on to IAgrM was in order to concentrate on its clearly mandated core role of recognising excellence and making awards. Council will no doubt review its position on this and other matters, especially of policy commented upon.

6. Discussion

It is clear that respondents in our survey are conscious that collectively we have a huge pool of diverse practical and relevant experience available for the benefit of agriculture. They represent 49% of current membership of The Fellowship of Royal Agricultural Societies administered by CARAS. There is a strong sense that this pool needs to be harnessed to impact the public, policy-makers and the research and development agenda more effectively. However, many members recognise that those who hold CARAS awards are already engaged through many other agricultural and rural organisations and thus exert their influence, and maximise the ‘reach’ of CARAS. Concern to help younger people in agriculture and to recognise potential Associates at an earlier age is common to all four nations. Some of the policy suggestions made would require members to take initiative and responsibility to implement, such as more interaction together and sharing of information, whether by seminars or via the website. Other matters require Council decisions regarding its policies. Overall, its present procedures and standards are endorsed and it can take heart from that while not being complacent that there is much food for thought about its future activities and aspirations. The hypotheses that this peer recognition inspires, motivates to constructive action and improved management, strengthens mutuality, educates and fosters sharing of knowledge/information and enables communication between leading agriculturalists are confirmed by the responses, which show high percentages in agreement (Table7 and Appendix 2).

7. Conclusions and recommendations

While not being a lobbying organisation, as with pressure groups, the Fellowship of Royal Agricultural Societies is a source of independent practical knowledge and information and can advocate for agriculture and rural well-being when and where necessary with suitable diplomacy. More publicity about what CARAS has to offer is clearly mandated by this survey, and perhaps merits each National Panel appointing one of its members as champion for PR and Press/media liaison, as well as Council itself appointing one of its number to that role. Members from each nation have expressed the need to recognise outstanding candidates at an earlier age. England already considers all Nuffield Scholars as they complete their scholarship Reports and pursue further contributions. It is worth remembering that Pitt was Prime Minister at 24, while Mozart was dead at 35!

The average age of members in this survey must be viewed in relation to the fact that healthy agriculturalists tend to live to ripe old ages and that members can continue in the Fellowship for life. Nevertheless, there is clear impetus to search earlier among high achievers who evidently are contributing in distinguished ways to agricultural progress from their early thirties.

It is hoped that this Report may encourage agriculturalists in other parts of the world if no such scheme exists to develop a scheme for peer recognition elsewhere. Agriculture is a vocation that merits such a motivational incentive for the public good of future generations.

About the authors

Malcolm Stansfield is a past President of IFMA and serves on its Council. He was a Visiting Professor at the Royal Agricultural University, Cirencester and was the longest serving staff member of the University of Reading when he retired as Director of the Farm Management Unit. He is Hon. Secretary of the CARAS English Panel, and works much within farming.

John Wibberley runs his own business since 1989 and is a Visiting Professor at The University of Reading & at The Royal Agricultural University, Cirencester. He works in agricultural resource management and extension in UK & abroad. Since 2000, he is Hon.Sec. & part-time Coordinator UK Council for Awards of Royal Agricultural Societies (CARAS).

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Appendix 1

CARAS IMPACTS ON YOU & OTHERS: EVALUATION QUESTIONNAIRE Jan.2017

CARAS exists to **recognise outstanding contributions** to UK Agric. Progress & make Awards.

Does the existence of the CARAS award scheme motivate agricultural progress? How does being an **Associate** or **Fellow** influence your ongoing contributions to agricultural well-being & public good? Please complete & return this form **with your 50-word personal profile** in the SAE provided **by January 27th 2017** to: Professor John Wibberley, Hon Sec. **Thanks!**

A). **Please give Your full name, contact e-mail address, best telephone number(s) & Age** in box:-

Name:	E-mail:	Tel:	Age

B). Please underline of which YOU are a member? : Scotland / England / N. Ireland / Wales

C). Please **tick** appropriate column to indicate ***your views*** of aspects of your CARAS award/scheme

Topics on which your opinion is sought:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
A. Possible CARAS recognition inspired me B. My CARAS recognition encourages me still C.CARAS motivates me to collaborate with others D.CARAS motivates me to promote Agriculture plus E.CARAS scheme is for ultimate Public good F Advancing A to FRAgS needs far more extra output G.CARAS must stick to its core **Awarding** role H. It's good CARAS recognises Agric. **Plus** other rural I.CARAS motivates better work standards J.CARAS fellowship is enjoyable K.CARAS involvement stimulates creative thinking L.CARAS involvement stimulates positive action M.CARAS widens my Agric./Rural understanding N.CARAS exposes me to other Agric. opinions O.CARAS sharpens my resolve to learn more P.CARAS urges me to contribute more to life Q.CARAS standards are kept with rigour R.CARAS policy to ***invite*** applicants is right S.CARAS members' varied Agric. links are good T.CARAS website is a welcome development U.I intend to use CARAS website V.CARAS March & July mailings are enough W.CARAS should celebrate its Jubilee in 2020 X. Members should attend their National Panel events Y.CARAS scheme is widely understood by outsiders Z.OTHER?					
What specific matters would best improve CARAS?					
What, if anything, would you like CARAS to add to its role, noting that it's NOT a lobbying group?					
PLEASE provide a 50 WORD PROFILE to describe your present activity for the CARAS Website:-					

Appendix 2

Level of Agreement on Opinion Topics Requested

PERCENTAGE Agree + Strongly Agree : n =	**204**	**37**	**98**	**111**	**74**	**15**	**30**	**24**
** **see Note below**	**EF**	**NIF**	**SF**	**WF**	**EA**	**NIA**	**SA**	**WA**
Topics on which your opinion is sought:								
A. Possible CARAS recognition inspired me	73	76	70	76	75	62	69	83
B. My CARAS recognition encourages me still	90	89	74	89	85	85	97	96
C. CARAS motivates me to collaborate with others	62	91	58	68	69	62	62	91
D. CARAS motivates me to promote Agriculture plus	73	94	67	84	71	77	79	91
E. CARAS scheme is for ultimate Public good	82	97	70	76	81	77	69	69
F. Advancing A to FRAgS needs far more extra output	47	64	48	68	49	46	24	43
G. CARAS must stick to its core **Awarding** role	65	73	68	80	61	54	66	83
H. It's good CARAS recognises Agric. **Plus** other rural	77	80	85	90	82	92	86	87
I. CARAS motivates better work standards	60	67	58	72	70	77	78	69
J. CARAS fellowship is enjoyable	86	97	97	98	85	85	100	78
K. CARAS involvement stimulates creative thinking	78	94	78	86	82	77	86	83
L. CARAS involvement stimulates positive action	68	86	81	73	72	77	85	83
M. CARAS widens my Agric./Rural understanding	76	100	79	76	73	77	89	87
N. CARAS exposes me to other Agric. opinions	82	100	89	88	80	92	100	83
O. CARAS sharpens my resolve to learn more	55	83	62	79	64	85	86	83
P. CARAS urges me to contribute more to life	54	82	56	71	57	77	83	87
Q. CARAS standards are kept with rigour	64	88	61	78	71	77	75	78
R. CARAS policy to ***invite*** applicants is right	86	89	84	87	82	77	90	78
S. CARAS members' varied Agric. links are good	93	100	92	90	89	85	90	91
T. CARAS website is a welcome development	82	86	76	85	82	54	90	83
U. I intend to use CARAS website	66	71	69	73	77	54	86	87
V. CARAS March & July mailings are enough	80	80	69	81	76	46	79	74
W. CARAS should celebrate its Jubilee in 2020	88	97	84	93	88	75	93	100
X. Members should attend their National Panel events	57	91	74	83	53	64	63	74
Y. CARAS scheme is well understood by outsiders	2	12	4	9	7	0	12	0
% Providing Website entry	88	81	77	87	81	80	90	90

Note: Associates = A; Fellows = F; and **E, NI, S, W = England; N Ireland; Scotland; Wales.**

DOI: 10.5836/ijam/2017-06-80

Involving stakeholders in agricultural decision support systems: Improving user-centred design

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ABSTRACT

Decision Support Systems (DSS) can improve farm management decisions and offer the opportunity to improve productivity and limit environmental degradation, both key tenets of the sustainable intensification of agriculture. While DSS are becoming increasingly useful for agriculture, the uptake of computer-based support systems by farmers has remained disappointingly low as evidenced by studies spanning at least two decades. This paper explores the reasons behind this continued lack of interest. Is it, as previous researchers have proposed, the lack of user involvement in the design and development of these systems? If so why should this be the case given decades of evidence underlining the value in user centred design (UCD)? The paper reviews literature on the desirable characteristics of DSS, and then uses 78 interviews and five focus groups to explore a case study of system use. The paper suggests that without changes to how systems are developed, particularly in how users are consulted, use of this technology will continue to be low. Practical suggestions are proposed to encourage more effective user-centred design. Chief amongst these, the need for designers to undertake a 'decision support context assessment' before building and launching a product is highlighted. Better knowledge of user-centred design practices, a clear understanding of advice systems, and greater collaboration with human-computer interaction researchers are also required.

KEYWORDS: decision context assessment; decision support systems; decision support tools; participatory research; stakeholder engagement; technology use; user-centred design

1. Introduction

Decision support in agriculture

Researchers in the environmental sciences have found that despite the availability of scientific knowledge, relatively little science is used by practitioners (Dicks *et al.*, 2014). Thus, there is a need to find a way of linking science and practice better, and decision support systems (DSS) are a suggested solution. These are usually software-based, guiding users through clear decision stages using an evidence-based database to support recommendations. In agriculture, DSS for use on-farm are seen as part of a solution to the problem of delivering scientific knowledge directly to the farming community to raise productivity and reduce environmental impact (Rose *et al.*, 2016). Their potential to improve farming decisions are well-recognised (Kragt and Llewellyn, 2014), and if properly designed, Lindblom *et al.* (2017, 311) argue that 'AgriDSS can promote and scaffold environmentally sustainable… decisions'. Despite their alleged value and their availability in a wide range of formats, the actual uptake of computer-based DSS by farmers has been low (Rose *et al.*, 2016). As one farm adviser argued in a focus group for this research (see 'Methods'), 'the pathway to sustainability is littered with the burning wrecks of failed decision support systems'.

Interest in the reasons for failure of this apparently useful technology is not a new phenomenon. DSS and their predecessors, 'Expert Systems', have been considered an option for delivery of science since the early 1990's (e.g. Jones, 1993) and concerns about the lack of uptake by end users have been raised since then. In agriculture, several studies have investigated factors influencing system use (Kerselaers *et al.*, 2015; McCown, 2002; Rose *et al.*, 2016). Alvarez and Nuthall (2006) suggested that specific farmer attributes (e.g. education, skills) and the size of the business were strong determinants of DSS success. Others such as McCown (2002) have argued that the function of the system in relation to the decision task is the key factor: systems which seek to replace the decision-makers' decision processes are resisted, whereas those which present themselves as a tool are more likely to be adopted.

Original submitted February 2017; revision received May 2017; accepted September 2017.

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Box 1: Desirable characteristics of DSS in agriculture (Rose *et al.*, 2016)

	Desirable characteristics
1	Performance
2	Ease of use
3	Peer recommendation
4	Trust
5	Cost
6	Habit
7	Relevance to user
8	Farmer-adviser compatibility
9	Awareness of age
10	Awareness of business scale
11	Awareness of farming type
12	Awareness of IT eductation
13	Facilitating conditions
14	Compliance
15	Level of marketing

The importance of ensuring the compatibility of the system to existing farm practices and technologies is stressed by Aubert *et al.* (2012).

Rose *et al.* (2016) found many of the same influential factors. Fifteen key factors were distinguished (see Box 1).

Participatory approaches/User-Centred Design as a solution

Parker and Sinclair (2001) argued that the reason for lack of uptake was the approach taken to the system development, which had limited understanding of decision-making in practice (see also Lindblom *et al.*, 2017; Rodela *et al.,* 2017). They proposed that the technology-centred methods adopted by many developers were the main reason for the mismatch between the tool delivered and the needs of the end-user. In an ethnography of a software manufacturer, Woolgar (1990) concluded that the lack of UCD of many systems occurred as a direct result of the disconnect between designers and users. This problem was noted by Cooper (1999) who proposed the now well-established design tool of Personas as local fixed representations of key user characteristics and needs.

Parker and Sinclair (2001) concluded that the logical approach to reducing barriers to use would be for DSS developers to adopt user-centred design (UCD) methods, which are widely discussed in human-computer interaction (HCI) research. Although HCI researchers have rarely engaged in agriculture (Lindblom *et al.*, 2017), a UCD approach involves an assessment of the decision-making environment in which decisions are made, including finding out about the workflows of end users. Conducting such a decision context assessment is a key hallmark of UCD, ensuring that systems are adapted towards existing user needs and workflows, rather than trying to force users to change routines (Allen *et al.*, 2017; Aubert *et al.*, 2012; Evans *et al.,* 2017; Lindblom *et al.*, 2017). Evidence from fields such as agriculture (Kragt and Llewellyn, 2014; Oliver *et al.*, 2017; Rossi *et al.*, 2014), and public health (van der Heide *et al.*, 2016), strongly suggests that adapting the tool to existing workflows, and consulting users throughout, is more effective than expecting users to change their behavior. Understanding use workflows is also important to ensure that technologies are relevant to user needs (Weatherdon *et al.*, 2017).

In coastal risk management, Santoro *et al.*, (2013) found that involving users at the beginning of a project to design DSS was essential to meet stakeholder needs. In medicine, UCD methods have also been shown to have a beneficial impact. For example, Thursky and Mahemoff (2006) used a range of UCD techniques in the requirements identification and design stages of an antibiotic prescribing DSS for Intensive Care Unit use. The careful attention taken by the developers to the existing tasks and work patterns of the intended users resulted in a design which substantially reduced the time taken to perform the prescribing task and was thus rapidly adopted into practice.

The problem of validating the impact of user participation

One of the problems in reviewing the issues around uptake, and the value of any particular approach to system development, is that there is little discussion of actual system use within the scientific literature (van Delden *et al.,* 2011). While there are many papers describing DSS within agriculture[5], most focus on the development of systems or innovations in modelling. While this in itself underlines the technology driven nature of DSS development, it makes it difficult to find studies supporting or disproving the notional value of UCD. A good example of this is a piece of work by Oliver *et al.* (2012). Based on a case study of farmers in the Taw region of Devon in the UK, these researchers investigated the role of farmers in designing DSS. They argued that six stages were needed to include farmer knowledge in the design of systems, but follow-up research on whether a trial of this process had improved uptake was not carried out. Despite limited investigations into the effect of UCD on DSS adoption in the long-term, however, a few studies contained within a review by Lindblom *et al.* (2017) do support the link.

In order to elucidate further the role of UCD practice in agriculture, two studies are described in this paper. The first reviews the literature for determinants of success in those DSS that have had active use. The second takes a case study approach to reveal the extent to which farmers and advisers are being consulted in the design of DSS. The output from these investigations is used to promote the value of UCD approaches in DSS development, including better collaboration between agricultural scientists and HCI researchers.

2. Methods

Structured literature review

A literature review was conducted to assess the factors found to be influential in encouraging successful uptake of DSS in a range of disciplines. To place emphasis on user data rather than theory, the review focused on papers that provided evidence that the described systems had been in actual use. Sectors of particular interest are: health, which shares a concern with biological systems; construction, whose activities are similarly impacted by weather; and manufacturing, which shares a focus on production processes. The search was limited to 20 years (1994–2014), and there were four attributes for the initial search:

a) Relevance to decision support. For this a set of terms was used, which were previously validated in a similarly focused systematic review (Wu *et al.*, 2012).

[5] A basic search on the Web of Science database at the time of writing generated over 3000 results.

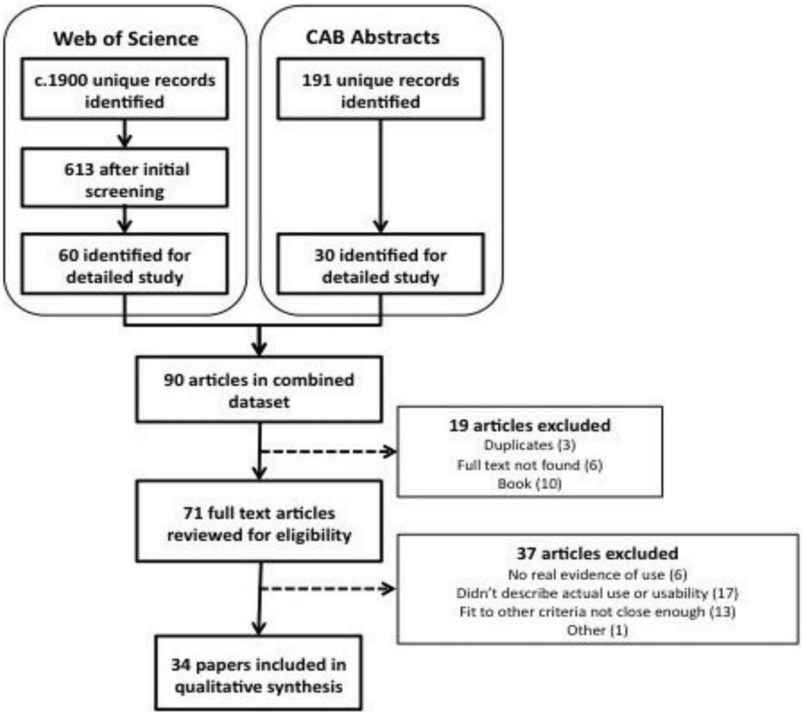

Figure 1: Filtering process used in the selection of papers for the literature review

b) A focus on systems that had been in active use.
c) An evaluation of the success of the system in use.
d) An evaluation focused on the end user.

An overview of the process is illustrated by Figure 1, and further details of the review process are detailed in appendix 1.

DSS uptake in agriculture: an English and Welsh case study

A case study of the use of DSS in English and Welsh agriculture was selected to act as a microcosm for system use in agriculture. End users in this case were defined as farmers, but also professional advisers. Studies have shown that a farm adviser's role in encouraging efficient farming practices is now more central than ever, and their advice is highly valued by farmers (AIC, 2013; Ingram, 2008; Prager & Thomson, 2014). One of their roles can be to encourage farmers to take up new innovations (Jakku & Thorburn, 2010).

Five focus groups lasting up to an hour were held with arable farmers (2), arable advisers, dairy farmers, and red meat farmers. These made use of existing networks of farmer/adviser meeting groups. They were typically attended by 10-15 individuals and were recorded and transcribed. The focus groups centred on the use of DSS, posing questions such as 'do you use DSS?', and 'what influences you to use a new DSS?'. Through group interaction, the factors affecting uptake were discussed, as was the level to which end users felt included in the processes of design and delivery.

For a more in-depth personal view of the use of DSS, and the place for UCD, 78 semi-structured interviews lasting up to an hour were conducted with farmers and advisers in three different study regions across England and Wales (Wensum in Norfolk, Taw in Devon, and Conwy in North Wales). Of these 78 participants, 33 were arable or livestock advisers, and 45 were farmers covering the arable (14), upland livestock (Less Favoured Areas (LFAs) - 19), and lowland livestock sectors (9), but also including dairy (3). These entreprises were chosen as they covered the largest area of land in the UK as compared with entreprises such as horticulture, pigs, and poultry. The farmers were recruited from a survey completed by 244 farmers (across 7 study regions, see Rose *et al.* 2016) as part of Defra's Sustainable Intensification Platform. The adviser sample was generated with assistance from ADAS, who used existing contacts and search engines to develop a list of advisers covering each of the three study areas. These included advisers who provided technical, business, or environmental advice, and included both commercial and independent advisers (see Rose *et al.*, 2016). The interviews asked a number of questions relating to use of DSS, and their semi-structured nature facilitated wider discussion of the researcher-user divide.

3. Results

Literature review

A total of 34 papers were reviewed in the final analysis. The issues identified by each paper as contributing to success, or presenting a barrier to use, were manually clustered and 15 factors emerged. Within each factor duplicate issues were removed to leave a set of distinguishable attributes. Table 1 illustrates that there are clear benefits to designing a system that is easy to use, fits the existing workflow of users, performs well, and commands trust. As a barrier to system use, a poor user interface was the most prevalent obstacle to continued use, whilst a DSS that performed well and provided clear benefits to use was the most important characteristic for successful uptake. In the list of factors, there is a clear focus on the user; for example, a good user interface, a system that fits

Table 1: Results from literature review

Factor heading	Number of times each factor listed in final article set		
	As success factor	As a barrier	Total
Usability/UI design	18	16	34
Fit to task/workflow	16	14	30
Clear benefits to use	19	3	22
Trust/confidence in system	9	8	17
Integration with existing systems/databases	8	3	11
User-focused design	9	1	10
Organisational/peer support	9	0	9
Decision support design	8	0	8
Responsiveness to user comment/issues with system	7	0	7
Training/launch timing	5	2	7
Technical support	3	2	5
Marketing	2	2	4
Job security/job status	2	2	4
Access to software/hardware	2	1	3
Keeping knowledge data/current	2	1	3

end user workflow, user-focused design, responsiveness to user, and peer support. This suggests that better UCD of systems would be beneficial.

Case study of DSS use in UK agriculture

Although Oliver *et al.*, (2012) suggest that agricultural research has shifted towards participatory methods for both the design and implementation of DSS, the empirical case study used here suggests that lessons are still not being widely learned. On UCD, data from both the focus groups and interviews suggested that user-focused practices were not widely utilised. A common theme referred to the perceived divide between developers (including researchers) and end users. The lack of interaction between these two groups therefore restricted the extent to which users were consulted. One arable adviser argued that:

> ‘Decision support tools aren’t about giving advice to individual farms, they’re just about taking knowledge from clever people’s heads and then building a computer programme.’ (Arable adviser, focus group)

This viewpoint was backed up by several farmers, including a farmer in Devon. He argued:

> ‘I’m perfectly happy to come to your university and give a lecture in common sense. I learn from the university of life. Sometimes I feel the researchers who design these things need a bit of common sense. Ask yourself will it work on a farm? Have I ever visited an actual farm?’ (Lowland livestock farmer, Taw, 10011)

Similar responses were received in several interviews. For example, a farmer was annoyed by the lack of engagement from developers of systems:

> ‘I’ve been doing this forty years, you get some academic who’s come out of college last year and they’re telling me what to do. I just laugh at them, I think you stupid idiot you haven’t got a clue.’ (LFA farmer, Conwy, 20034)

Further discussion in both focus groups and interviews illuminated the impacts of the farmer/researcher divide, but also highlighted the value of trusted advisers (e.g. agronomists, vets) in contrast to ‘outsider’ researchers. Indeed, throughout the research it was clear that trusted advisers were key to the use of decision support systems (Rose *et al.,* 2016), as noted by other studies of system uptake (Evans *et al.,* 2017).

As a result of low user engagement, technical support tools were designed that were not easy to use or tried to solve the wrong questions. Or DSS required long hours in the office to operate effectively, which did not fit the workflow of small-scale farmers who “make their money getting outside and getting stuck-in” (Red Meat Focus Group). There was also a lack of trust between farmers and researchers.

These opinions reinforce the claim by Parker and Sinclair (2001) that design of DSS is not always user-centred. They remind us of the ‘transfer of technology’ approach; one in which a sophisticated system is designed in an ivory tower, assumed to be useful for end users, and rolled out with little regard for end user involvement or the decision environment into which the system is launched.

‘ToolX’ – a User-Centred Nutrient Management System

A farm adviser was interviewed who provided advice to local farmers about using DSS. He encountered problems with a specific software package, which was designed to help farmers with nitrogen application. This package answered relevant questions, and it was free to download. However, it was not easy to use. Echoing criticisms of the systems from other interviewees who described it as a ‘nightmare’ (Livestcok adviser, 2), the adviser reported that:

> ‘I had 27 farmers in the programme. The first day I would think by the evening most people had lost it. So I did another one and within six hours they had lost it again. Farmers couldn’t understand it, they could hold the information for about half a day. So, I gave up on it and decided to design my own.’ (Livestock adviser, Taw, 11)

Interviewees suggested that the original system design had made little use of end users. In order to improve the user interface, the adviser set out to involve end users throughout the design of a new system (‘ToolX’).

Crucially, however, he approached the design of a new prototype from a user perspective. He had learned to see flaws in the old system as a result of end user input, and therefore his initial work on the new tool was driven by the user.

Initially, the new system was designed in a basic Excel© spreadsheet. This was then taken to local farms for input from farmers, as illustrated by the following extract:

> 'We tried this basic design on farmers. From the very beginning farmers had to test it and use it. We asked them see if you can go and break it and then come back to us with things. One comment was you've forgotten to put a decimal point in these values!' (Livestock adviser, Taw, 11)

Over the course of the design project, farmers made several suggestions including, (1) changing the given units, (2) improving the ease of data entry, (3) allowing mistakes to be undone easily, (4) providing the ability to deal with multiple fields at any one time, (5) ensuring that a technical helpine was set up. By tweaking the design to take into account these user preferences, initial trials seemed positive. The adviser stated that 'within 10 minutes most farmers can crack this and even if they don't look at it for a while, even for three months, they can go straight back into it'. Whilst some caution may be prudent in announcing success before widespread uptake, the UCD process seemed to have satisfied some of the important determinants of uptake identified in Box 1 and Table 1; specifically, usability, user-focused design, technical support, and responsiveness to user. Furthermore, trust was built through the design process.

4. Discussion

Returning to the top ten factors identified in Table 1, UCD processes would seem to be highly relevant. Taking these in turn, it is possible to see how UCD could contribute to success in each category:

1. *Usability* – defined in HCI literature (ISO 9241-11) as 'the extent to which a product can be used to achieved specific goals with effectiveness, efficiency, and satisfaction in a specific context of use.' Evidence from HCI shows that UCD approaches achieve good usability (Andreasson *et al.*, 2015). Systems will be more effective and efficient, and users more satisfied if they play a role in development.
2. *Good fit to the decision task and workflow* – since developers will have a clear understanding of the decision-making environment and how the decision maker(s) would like the systems to fit in.
3. *Demonstrable value* – since only systems that offered value would be supported by users. Their input would ensure that the right questions were answered.
4. *Trusted output* – Trust in DSS output can be increased by participation in its design (Guillaume *et al.*, 2016).
5. *Integration with other systems used within the task* – through interaction with users, developers will understand what other systems the DSS needs to work with.
6. *User-focused design* – the outcome of a UCD approach.
7. *Peer support* – a good UCD strategy can bring together users and facilitate knowledge exchange (Oliver *et al.*, 2017).
8. *Decision support design* – the mechanisms by which decisions are supported (graphics, data, layout, extent of interactivity, etc) will be directly linked to need.
9. *Responsiveness to user* – awareness of the expectations of a range of users supports flexible and responsive design.
10. *Training* – understanding of existing levels of knowledge will inform training and participant users will have the knowledge to train others.

The apparent success attributed to the UCD of 'ToolX', for example, mirrors other research projects in agriculture that have encouraged participatory engagement. It is encouraging to see that some examples are recent in nature, and therefore perhaps the user-cented design message is getting across. Oliver *et al.* (2017), for example, report on a stakeholder-driven approach to the development of a DSS to visualize *E. coli* risk on agricultural land. By using a series of stakeholder workshops at every stage of the project (conception, design, testing, and plans for continued engagement), the developers were able to design a relevant tool with strong usability. Feedback was welcomed throughout the project and the tool was adjusted in line with user preferences (e.g. desire for ease of use). The process built trust and an excellent rapport between researchers and users. The ability of users to scrutinize decision support systems, and suggest refinement, is also mentioned by Bruce (2016) and Lacoste and Powles (2016) as important in system design. Furthermore, Guillaume *et al.* (2016) suggest that a participatory approach can help to build trust, which far outweighs the inconvenience of a more time-consuming research project. Oliver *et al.* (2017, 233) conclude with the argument that involving stakeholders within all stages of…design… from inception and idea formulation through to testing, is critically important'.

In addition, Rossi *et al.* (2014) report on a project to design a DSS ('vite.net'®) for vineyard farmers in Italy. By involving potential users during its development, researchers were able to gain insights into how users make decisions, and where their tool might fit in with their decision-making routines. Feedback suggested that potential users were likely to use vite.net®, but the paper did not investigate continued uptake in the long-term. Higgins (2007) also illustrates how participatory engagement with farmers helped a Dairy Planning Software (DPS) system Australia. In this project, farmers were invited to workshops to input their own data and the DPS was configured according to this. This made the tool relevant to particular users and gave the farmers ownership of the process. As a result, farmers gained validation of their knowledge and felt empowered by being included in the project. The workshops also enabled farmers to give feedback on the tool, and the DPS was modified in response to criticisms.

The problem with such studies, and the major caveat of this paper, is the lack of long-term engagement with the effects of UCD. For the project described by Higgins (2007), for example, Eastwood *et al.* (2012) suggests that there was limited continued engagement with farmers. Likewise, Oliver *et al.* (2012) argued for the adoption of a specific user-centred strategy of DSS development in Devon (UK), but were not able to test this in the long-term. Certainly, more research is needed that traces a UCD project from conception through delivery and onwards to investigate whether there is sustained used. It is worth noting also that trade-offs between including the views of stakeholders and sticking within a design timetable may be needed, and furthermore designers should have some capacity to innovate since they are best placed to know about technical possibilities (Santoro *et al.* 2013). If we are to accept, however, that the UK case study presented here illustrates many of the same UCD flaws identified by Parker and Sinclair (2001), the experiences of farmers in relation to DSS do not seem to have changed. It is interesting to ask why UCD might not be practised widely.

Lack of knowledge and skills about how to do UCD may be a factor (Lindblom *et al.*, 2017). DSS in agriculture are rarely if ever developed by an established software design team, particularly in the case of a university-driven piece of work. There may be some commercial software development experience within a DSS design team but very often, in the UK at least, the developers will be a small team of scientists which includes, or has access to, individuals with programming capability. It is unlikely that any of the team will have knowledge of UCD methods even if they contain experienced software developers (Lindblom *et al.*, 2017). Indeed, even in mainstream software development it has been shown that the majority of mainstream software organizations perform few usability engineering activities or none at all.

The nature of funding might also be an issue. Since the mid 1980's the funding for agricultural science in the UK and elsewhere has moved away from industry focused research institutes and into universities. At the same time the pressure on researchers to publish has increased and sums of money spent on agricultural research has decreased (Leaver, 2010). Weighing up the costs of UCD against the less tangible benefit of user uptake, a factor which is of less value to the UK research scientist than a peer-reviewed publication (Bruce, 2016), then it is perhaps not surprising that UCD is not widely employed. Even when user involvement has been specified by the funding agency, the level of participation or influence by the users on the final design may be less than optimum. Since DSS, therefore, are being designed in research institutions away from the farm environment in which they are used, the practical decision-making environment is not well understood. Decision support context assessments (Fig 2) are rarely carried out and this increases the chances of poor design.

Encouraging UCD of agricultural DSS

Based on the findings, four recommendations are suggested to improve the quality of UCD of DSS in agriculture and beyond.

1. Promote user-centred design practices

Providing guidance for developers to take UCD seriously from the outset, will help to prevent costly uptake problems at a later stage. The how, why, and when of user involvement are important concepts to clarify with those engaged in DSS development; particularly since studies show a link between user engagement, which uses good communication and focuses on stimulating learning, and uptake of DSS (Evans *et al.*, 2017; Oliver *et al.*, 2017; Rodela *et al.,* 2017). For those developers who are not familiar with effective user facilitation approaches, several useful guides exist on how to engage stakeholders effectively (see review by Reed, 2017). As research by Lynch and Gregor (2004) shows, it is the depth of user influence on design, rather than simple participation that is important. Developers need to be helped to understand not only the benefits of engaging with users during a project (Lindblom *et al.*, 2017), but also at the concept stage and after implementation. Funders and development teams alike need to be made aware that on-farm installation of a DSS is only the beginning of the story (Eastwood *et al.*, 2012), as the lack of continued engagement is responsible for many failed projects. After installation, a DSS must be consistently updated to maintain accuracy (not easy if funding ceases) and developers need ways to maintain the motivation and skills of farmers.

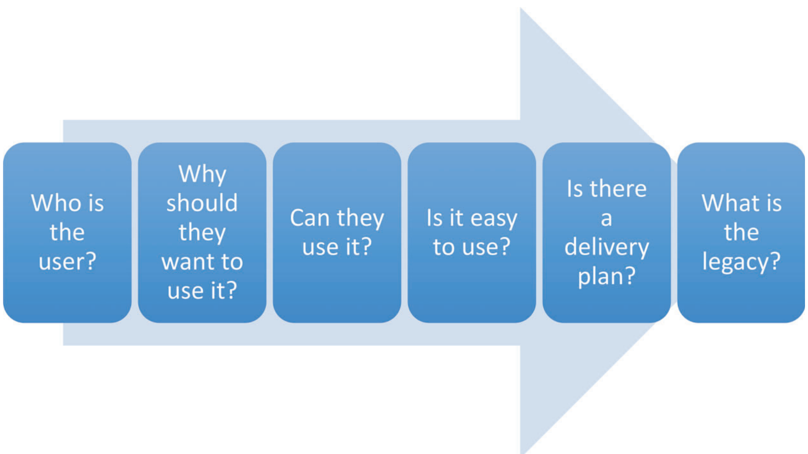

Figure 2: Key Stages in a Decision Support Context Assessment – **1) Who is the user?** – identify a clear user, understand their workflows, and ask about their needs; these will vary for different types of farmers, 2) **Why should they want to use it?** – scientifically, the system might be robust and impressive, but ask whether there is a need for it from a farmer/adviser [user] perspective – asking users whether they need it would help! 3) **Can they use it?** – test whether users are able to use it effectively; also find out whether users can practically use it in a given setting (e.g. is there internet access on-farm?), **4) Is it easy to use?** – related to point 3, however there is a distinction between merely being able to use it, and the ability to use it easily – ask about user design preferences and test tools on actual users rather than like-minded colleagues, **5) Is there a delivery plan?** – ask how farmers/advisers [users] will find out about the system.This might involve making use of existing trusted peer and adviser networks, (6) **What is the legacy?** – if the tool needs to be consistently updated to maintain relevance, then consider how to do this once funding ends.

The nature of funding within this sector in the UK has increasingly placed the task of communicating science on an academic group who have little regular direct contact with end-users. Funding bodies should insist that a 'decision support context assessment' (Figure 2) is undertaken before the design and delivery of a DSS to ensure impact. This will prevent the costly and time-intensive design of unsuitable systems.

2. Encourage cross-disciplinary collaboration with HCI researchers
Lindblom *et al.* (2017) argue that HCI researchers could take a greater interest in agriculture. The knowledge of how to design appropriate and useable systems contained within HCI could be usefully shared with agricultural researchers and developers of decision support. This requires engagement from both communities and a commitment to multi-disciplinary research collaborations, encouraged by the funding landscape.

3. Undertake decision support context asssessments
In addition to promoting the need for UCD, designers of agricultural DSS will need guidance on how to do it. As shown by Allen *et al.* (2017), even when user-centred methods have been used, projects still suffer from a mismatch between stakeholder and researcher expectations. Furthermore, a review by Rodela *et al.* (2017) found that existing user engagement exercises were not underpinned by a coherent methodology. As the results in our study indicate, many systems are poorly targeted, and do not include the end user. From a relevance and usability perspective, systems therefore ask the wrong questions and do not solve problems in an efficient, effective, and satisfactory way.

Given the largely non-commercial and/or low budget nature of DSS development, the solution to this problem may be to create freely available templates (i.e. outlines of UCD tasks with instructions suited to specific types of project), or basic guides to UCD to support developers. These templates would need to be flexible enough to meet the varying demands of a range of project sizes and user access capability, cost-efficient to encourage use (Kujala, 2003), and sufficiently detailed to support a team without any prior knowledge or experience of UCD (Lindblom *et al.*, 2017). A basic template for a 'decision support context assessment', illustrated in Figure 2, should be used by designers throughout the project, and funders should make grant holders report on whether, and how, they have considered each stage. We consider the process outlined in Figure 2 to be relevant for the design of DSS in all fields; crucially, the user must be involved at every stage.

The template shown in Figure 2 encourages the engagement of end user at an upstream stage, and key user facilitation skills are required (see Reed *et al.*, 2017). This approach, described by Santoro *et al.* (2013) as 'involve to improve' may create better prototypes, as in the case of 'ToolX', and ultimately better final products. Following each stage on Figure 2 will satisfy many of the key enablers of success found in the literature review and UK case study; including ensuring that systems (1) fit farm workflows, (2) are easy to use, (3) perform a useful function, (4) are trusted, and (5) can integrate with other systems. These categories are satisfied because a decision support context assessment enables the developer to understand the end user, find out who they are, what problems they need solving, what their preferences are for useful interfaces, and where systems can fit into their existing workflows. This user-centred mentality is vital in the future design of DSS to ensure that we move away from a situation where 'clever people' are designing systems 'in their heads' (arable *adviser in focus group*), which are then unsuitable for use in practice.

4. Understand the governance of on-farm decision-making
As part of a decision support context assessment, developers need to discover the different actors making key on-farm decisions. This will always include the farmer, but it will also usually encompass a wider selection of actors, including paid professional advisers, industry representatives, and other trusted indviduals (AIC, 2013; Ingram, 2008; Prager and Thomson, 2014). Some of these groups, particularly paid professional advisers, will be more likely to use DSS that farmers (Evans *et al.*, 2017; Rose *et al.*, 2016). Since these individuals are usually trusted by farmers (Ingram, 2008; Evans *et al.,* 2017), mainly due to long-standing personal relationships, developers of DSS should make use of these existing trusted networks when delivering products. Building trusted relationships with such key knowledge brokers may allow developers to forge more trusted relationships with farmers by association.

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Acknowledgements

Research funded by Defra's Sustainable Intensification Platform (Code LM0201). WJS thanks Arcadia, LVD was funded by the UK Natural Environment Research Council under the Biodiversity and Ecosystem Service Sustainability (BESS) programme, grant code NE/K015419/1 and NE/N014472/1. We acknowledge Susan Twining, Charles Ffoulkes, Matt Lobley, Michael Winter, and Carol Morris, and others on the Defra SIP project.

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Appendix 1 – Structured literature review methodology

A structured literature review was conducted to assess the factors found to be influential in encouraging successful uptake of DSS in a range of disciplines. To place emphasis on user data rather than theory, the review focused on papers that provided evidence that the described systems had been in actual use. The search focused on Web of Science and Centre for Agriculture and Bioscience International (CABI) Abstracts database which give the best coverage of agricultural papers (Kawasaki, 2004). This strategy also allowed the project to learn from domains where DSS implementation, and the processes around it, are more mature. Sectors of particular interest are: health, which shares a concern with biological systems; construction, whose activities are similarly impacted by weather; and manufacturing, which shares a focus on production processes.

The search method was iterative with a starting point of a set of search terms generated by research and local knowledge. A reference librarian was employed to test the utility of these initial terms within the Web of Science database and to refine them into a more robust set. The papers returned during this first search were filtered according to pre-set criteria. The adjusted search terms were applied to CABI Abstracts and the same filtering process applied. The filtered output from the two searches was imported into Endnote™ and a more detailed review of full undertaken. Finally, papers that met the final criteria were reviewed in detail and a summary of their findings produced. There were four distinct attributes that articles in the initial search to contain:

a) Relevance to decision support. For this a set of terms was used, which were previously validated in a similarly focused systematic review (Wu *et al.*, 2012)
b) A focus on systems that had been in active use
c) An evaluation of the success of the system in use
d) An evaluation focused on the end user.

To keep the search space relevant and manageable the research domains selected for the search within the databases were restricted to Science, Technology or Social Science and articles published within the previous 20 years (1994-2014). The types of publication were not restricted. After several iterations in which the hit rate for various terms was analyzed the final search query developed within the Web of Science and then applied within CABI Abstracts was as follows:

(Decision support OR Decision system OR Expert system OR DSS) AND (Adopt* OR Impact OR Uptake OR "Take up" OR Usage OR utiliz* OR "Technology Acceptance") AND (Evaluat* OR review OR overview OR "lessons learned") AND (Users OR operator OR client OR stakeholder) NOT (consumer NEAR/5 "end product" OR fuzzy OR "electronic medical record" OR Techno* implementation)

Papers were filtered out if they did not appear to meet the intent of the four areas described previously. The reviewers also discounted papers that offered conjecture rather than evidence to support their hypotheses for why system failure/success occurred. Just over 2000 records were identified, a manual review and a check for duplicates between the two datasets reduced this to 71 articles. Each of these was reviewed in detail for fit to criteria particularly evidence and description of the system in use. 34 papers were used in the final qualitative analysis. An overview of the process can be seen in Figure 1.

The findings from each of the 34 final papers were summarized in an Excel™ spreadsheet using the following key characteristics:

- Paper ID (author, date)
- Domain (health, forestry etc.)
- Decision description (what area of decision making the system or review focused on)
- Evidence of use (e.g. in use for 5 years, 200 people used, etc.)
- Key characteristics for success (positively or negatively phrased)

Additional reference in appendix:

Kawasaki, J.L. (2004) *Agriculture journal literature indexed in life sciences databases. Issues in Science & Technology Librarianship Summer*, DOI:10.5062/F4M61H61

REFEREED ARTICLE

DOI: 10.5836/ijam/2017-06-90

The productivity of tropical grain production

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ABSTRACT

The objective of this manuscript is to understand better the nature of agricultural growth and productivity under a new tropical system of production, safrinha or succession cropping, which results in two large crops per year. The subject provides scholars and policymakers a technical foundation by which to think about the potential for market moving agricultural expansion and greater grain supplies originating from the tropics. Our results show that commercial tropical grain producers continue to rely on input intensification, principally chemicals, and extensification of their land base, and relatively low levels of technology, to increase grain production.

KEYWORDS: extensification; intensification; maize; productivity; safrinha; soybean; tropical

The global rise in demand for grains will increase competition for land, water, and energy, affect the world's ability to produce food, as well as necessitate greater vigilance on reducing food production's impact on the environment (Molden 2007; Lobell *et al.*, 2008; Godfray *et al.*, 2010). This paper focuses on new and emergent structures in grain production occurring in the tropics that sit at the nexus of the food demand-environment issue. Specifically using data from the most productive tropical region in the world Mato Grosso, Brazil (Goldsmith and Hirsch, 2006), we formally measure the level of agricultural productivity of soybean and maize production. We hypothesize and test whether a unique form of soybean and maize production, the ''safrinha system,'' achieves high levels of factor as well as total factor productivity. If true, the findings would indicate new growth and competitiveness opportunities for rural economies in the tropics.

Secondly, we hypothesize as to the source of any positive productivity gains, which has the practical implication of identifying whether the tropical expansion continues to reflect traditional extensive farming systems, which have negative environmental consequences, or whether the expansion might instead involve technology based intensification, which can be both environmentally and economically favorable. Our identification in this research as to the type and level of soybean and maize productivity, across all inputs, provides some of the first evidence as to the nature of modern commercial tropical grain production.

Literature review

Tropical environments contain some of the most valuable and sensitive native biomes (Baudron and Giller, 2014). As a result, land use changes in the tropics from native biomes to agriculture reflect major tradeoffs for policy makers: assuring a low cost and well-distributed food supply and bringing economic development to some of the poorest regions of the world versus reducing the adverse effects of deforestation on climate change; and maintaining the planet's biodiversity. Expanded production in the tropics raises not only land use change questions, but also introduces additional policy dilemmas related to the land sparing debate (see Cohn, *et al.*, 2014). Successful expansion in one area theoretically relieves the pressure to develop land elsewhere. This notion is the common ''postage stamp'' proposition that argues that sufficiently increasing agricultural productivity could, in the limit, allow the production of all the world's food in a very small area, a ''postage stamp.'' Thus some argue that if in fact tropical production can be highly productive, other lands may be deployed for alternative uses, including the preservation of native biomes (Phalan *et al.*, 2011). We are curious as to the level of productivity tropical soybean-maize systems achieve, because if highly productive then we may be witnessing a shift in the locus of global agriculture. Historically superior productivity resulted in the temperate regions in North America and Europe engaged significant land use change by clearing of forests and the plowing of prairies, which in turn released other regions from contributing to global grain stocks (Conway, 2001). Thus high productivity in the ''North'' spared land from development in the ''South.'' Raising tropical agricultural productivity through the development of new soybean-maize systems may change the land sparing equation.

The study of agricultural productivity commonly employs analysis of the relationship between outputs and inputs,

Original submitted May 2017; revision received November 2017; accepted November 2017.

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which has long been a subject of research. We refer readers to Fuglie (2004), Fuglie (2010) Rada and Valdes (2012) for a basic understanding of the approach. The TFP can be extended further to include revenue and cost shares to better match the manager's decision making process (Equation 1). Total output growth is estimated by summing over the output growth rates for each commodity weighted by its revenue and cost share.

$$\ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = \sum_i R_i \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) - \sum_j S_j \ln\left(\frac{X_{j,t}}{X_{j,t-1}}\right) \quad (1)$$

where R_i is the revenue share of the ith output and S_j is the cost-share of the jth input.

Of particular interest is not simply the relationship between inputs and output, but output per unit of land, which is yield, as well as the expansion of land used to raise output, extensification (Equation 2).

$$\underline{A} \qquad \underline{B} \qquad \underline{C}$$

$$\dot{Y} = \dot{X}_1 + T\dot{F}P + \sum_{j=2}^{J} S_j\left(\frac{\dot{X}_j}{X_1}\right) \quad (2)$$

$\dot{X}_1$ reflects the change in the size of the land base. Increasing output by adding land under cultivation reflects extensive growth, while increasing yield per unit of land reflects intensive growth, whether that be through greater productivity or increasing inputs per land unit. Rearranging terms within the TFP framework allows the identification of three elements of output growth; the addition of land, factor productivity and changing inputs. Output growth, $\dot{Y}$ becomes simply the growth in TFP plus the growth rates of land and the inputs multiplied by their respective cost shares. Empirically estimating the three components of growth, which we do, reveals the distribution as to the source of growth.

From 2001–2010, global output of total crop and livestock production increased by an average 2.5% per year (Figure 1). Globally, agriculture total factor productivity during the 2001–2010 period comprises 72% of global agricultural growth while input usage per hectare, expansion of agricultural land, and increased irrigation comprise 13%, 11%, and 4% respectively (Fuglie and Rada, 2013). Thus at the global level, the use of technology, whether physical or managerial, significantly raises agricultural output. The main source of output expansion has not been through the addition of more inputs, say chemicals, per hectare or expanding agriculture's land footprint, extensification. Thus, we hypothesize and analyze the following: Ho1: Tropical soybean and maize production follows the global trend and involves high levels of total factor productivity $(T\dot{F}P)$.

Increased yields, rising grain production, and higher incomes may cause farmers to expand their operations, thus increasing their land base (Southgate, 1990). Global trends though demonstrate that farmers don't employ an extensification strategy to meet growing food demand and increase the levels of profitability of their operations. Thus we hypothesize that land expansion (extensification) will play a minor role in the expansion of output by our sample of tropical producers. Ho2: Tropical soybean and maize production follows the global trend and involves low levels of extensification $(\dot{X}_1)$.

Finally intensifying production by increasing the level of inputs, especially crop protection, fertilizers, and fuel certainly raises output at the margin. Input intensification, while raising output per hectare and the productivity of land, labor, and physical capital, can have negative local, regional, and global consequences, such as increased erosion, lower soil fertility, reduced biodiversity, ground water pollution, eutrophication of rivers and lakes, and changes to atmospheric constituents and climate (Matson 1997). But positive input productivity can be land sparing worldwide if yield growth outpaces demand growth (Baker *et al.*, 2013). We therefore hypothesize at minimum positive productivity, or consistent with Ho1, high levels of factor productivity resulting from the use of technology across the set of inputs.

Ho3: Tropical soybean and maize production follows the global trend and involves positive levels of factor productivity $\left(\sum_{(j=2)}^{J} S_j\left(\frac{\dot{X}_j}{X_1}\right)\right)$ across the set of J inputs.

Methods

Researchers employ the number index approach, which holds revenue and cost shares constant over time, when

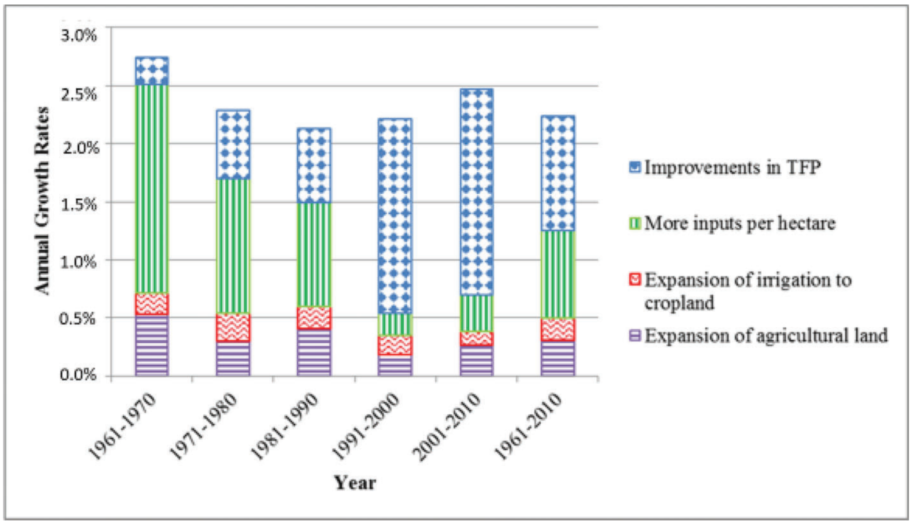

Figure 1: Global sources of growth in agricultural output, 1961–2010
Source: Fuglie, 2010.

prices and costs are not available, (see examples Evenson and Fuglie, 2010; Fuglie, 2010). The number index measure of TFP growth leads to ''index number bias'' in the measurement of TFP as producers change the combination of inputs and outputs in production in response to price changes.

Most analyses of total factor productivity commonly assume constant returns to scale which is necessary with national or aggregated datasets. Economies of scale is a firm-level assumption that does not apply to nations, and requires comparisons among firms to test (Evenson and Fuglie, 2010). Thus misspecification may take place because there may exist economies of scale among farm businesses (Kislev and Peterson, 1991). Additionally, input costs, prices, and revenue shares are assumed to be invariant and constant because data are aggregated at the national or regional level, when using such datasets (Fuglie 2010). The cost share weights often become fixed elements in the analysis of factor productivity. Homogeneous and time invariant prices and costs preclude a model specification that assumes that managers dynamically respond to changes in prices and costs, and thus shift both their input and output decisions.

We address these limitations by conducting our analysis using firm level data involving a cross section of dynamic cost shares and prices. Therefore, firm level analysis of total factor productivity becomes richer as it does not require a simplifying assumption with respect to returns to scale, revenue shares, and cost shares. Additionally, technological change may redefine the value proposition for input buyers, making price and cost determinations over time difficult, which has been a limitation in previous studies (Avila and Evenson 2010). For example, seed costs rise as maize seed containing transgenic technology substitutes for chemical inputs when fighting insect pests (Goldsmith 2001). Thus firm level data might reflect the dynamic switching by managers between chemicals and seed, depending on relative costs and perceived benefits.

Our model follows the Tornqvist index approach (Fuglie, 2004) and employs dynamic costs and prices, thus is more realistic. The Tornqvist index minimizes the effect of changes in price weights on output and input aggregation because weights are able to adjust over time as prices change. The Tornqvist index is more intuitive as managers will adjust input quantities based on both input cost and output price changes. We refine the components of Equation 2 above employing the Tornqvist index of simplified output (Equation 3), input (Equation 4), and total factor productivity growth (Equation 5), respectively, for year *t*:

$$\dot{Y} = \ln\left(Y_t/Y_{t-1}\right) = \sum_{i=1}^{n} \frac{\left(R_{i,t}+R_{i,t-1}\right)}{2} \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) \quad (3)$$

$$\dot{X}_1 = \ln\left(X_t/X_{t-1}\right) = \sum_{j=1}^{m} \frac{\left(S_{j,t}+S_{j,t-1}\right)}{2} \ln\left(\frac{X_{j,t}}{X_{j,t-1}}\right) \quad (4)$$

$$T\dot{F}P = \ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = \ln\left(\frac{Y_t}{Y_{t-1}}\right) - \ln\left(\frac{X_t}{X_{t-1}}\right) \quad (5)$$

Research setting

Intensification ratios reflect the number of crops per year average, which globally average less than 1.0 [per year (.82) (Siebert *et al.*, 2010). Within the last 15 years succession cropping (without irrigation), called ''safrinha'' in Portuguese, with an intensification ratio of 2.0 has emerged as a new farming system viable only in tropical settings. Succession cropping involves planting and harvesting two full crops per year on the same parcel of land. The safrinha system therefore involves ''benign'' extensification because while more hectares are planted, the land footprint remains unchanged. Successful development of these tropical grain systems provides the global community with a new land resource to meet rising food demand that is expected to double by 2050.

The planting and harvesting calendar in Mato Grosso differs from mid-latitude countries, such as the U.S. Tropical farmers plant soybean in the southern hemisphere anywhere from late September until late December and then harvest in mid-January until late April. But those who wish to produce two crops, plant prior to November 15 so that they are able to harvest the soybean, and then plant the maize crop in January and February (Goldsmith *et al.*, 2015).

Mato Grosso was a global deforestation hotspot in the early 2000's where active land clearing for agricultural expansion took place (DeFries *et al.*, 2013; Neill *et al.*, 2013). Deforestation though declined towards the end of the first decade of the 21st century through the combined effects of third party monitoring, government policies, and private sector initiatives that resulted in enhanced transparency and effective monitoring and enforcement (Fearnside, 2003). More importantly, these initiatives constrained land-clearing strategies (extensification) that traditionally had supported agricultural output growth.

Succession cropping represents, in part, a response to curtailed land availability that resulted from better deforestation control. Succession cropping differs from lower intensity single cropping, commonly practiced in temperate and sub-tropical settings, where farmers produce only one crop per year. Statewide maize follows soybean on 35% of the soybean hectares, almost doubling between 2008 and 2012 (Figure 2). Total safrinha maize production totals 19 million metric tons, which is about 2% of global supply.

Data

Previous studies on productivity growth in developing countries have limited access to reliable firm level data (Fuglie 2004; Fuglie 2008; Avila and Evenson 2010). Additionally, the lack of input and output quantities and prices limits productivity analysis. But the managerial decision making behind production decisions involves varying input usage and outputs based on the marginal productivity of an input and its relative cost, and relative output prices. So granular production, price, and cost data support the analysis of productivity, but often are difficult to obtain. As a result, there historically has been a lack of firm level agricultural data in Brazil, which constrains the detailed analysis of the TFP question (Gasgues and Conceição 2000; Gasgues *et al.*, 2004; Goldsmith, 2008; Avila *et al.*, 2010).

Two public agencies do compile statistics on the costs of production for the state of Mato Grosso, CONAB (Companhia Nacional de Abastecimento) and IMEA (Instituto Mato Grossense de Economia Agropecuária). But we only use these data for validation purposes

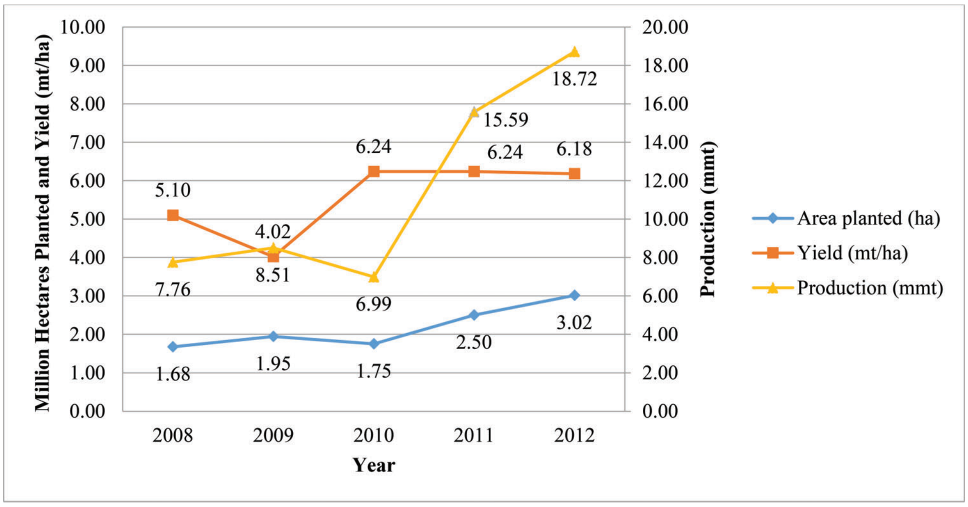

Figure 2: Mato Grosso safrinha maize production, 2008–2012
Source: IMEA and author's calculations.

Table 1: Comparison among the Reference Project, IMEA, and CONAB: soybean production averages – 2007–2012

Variables	Unit	Reference Project	IMEA	CONAB	IMEA difference
Land	(US$/ha)	77.83	142.93	131.79	–46%
Labor	(US$/ha)	48.32	15.87	34.69	204%
Fertilizer	(US$/ha)	221.36	264.32	261.07	–16%
Seed	(US$/ha)	56.37	50.2	46.02	12%
Pesticide	(US$/ha)	159.24	168.8	104.2	–6%
Diesel	(US$/ha)	43.99	–	–	–
Machine	(US$/ha)	53.36	24.06	52.67	122%
Aggregate inputs	(US$/ha)	675.96	666.17	630.44	1%
Gross revenue	(US$/ha)	1,077.18	1,146.43	492.92	–6%
Net return	(US$/ha)	401.21	480.26	–137.52	–16%
Grain price	(US$/mt)	331.26	367.45	164.31	–10%
Grain yield	(mt/ha)	3.25	3.12	3.00	4%

because price and cost estimates result from only a small phone survey of industry representatives; 10–15 participants along the entire value chain. The CONAB and IMEA data sets result from no direct interviews of, and data collection from, actual farmers to obtain actual prices received, costs incurred, or production decisions made (Anonymous 2010; Anonymous 2014).

This research addresses the data problem by using a unique firm level dataset derived from the Reference Project farms of the Maize and Soybean Association of Mato Grosso (Aprosoja, 2009). The data set provides the only detailed farm level income, expense, input, and output data available in tropical Brazil. The Reference Project began in 2007 to establish performance benchmarks for farmers in the state and provide the basis for a farm management training curriculum. The EPAGRI (Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina) program offered in the southern state of Santa Catarina serves as the model for the Reference Project (Spies, 2007). Aprosoja's team of regional technicians; train farmers how to use the data entry software, assist the farmers uploading their annual data, provide support in the form of data cleaning, summarize, analyze, and report the data for the benchmarking reports, and deliver farm management workshops (Aprosoja, 2015). Volunteer farmers apply, and about 40 are selected to be representative of the membership in terms of farming operation type, size, and geography (Aprosoja, 2010).

The database for this research comprises 43 farms producing soybean and maize between 2007 and 2012. The data include detailed costs, revenues, input quantities, and inventory values. Agronomic data and farm characteristics are also included such as farm size, share of different enterprises within the farm, percentage rented, etc. Estimates of the value of farm assets owned are made at the time farmers join the Reference Project. Depreciation plans are also part of the data collection process. The farmers upload their data into a central database using software provided by Aprosoja. Farmers have access to all the data online and so are able to see and correct data as needed.

From 2007–2012, the sample Reference Project farmers plant on average 1,632 ha of soybean, which is slightly smaller than the average of 2,000 for the state (Goldsmith, 2015). The Reference farmers produce 732 ha of second crop, safrinha maize. Thus 46% of total soybean land in the sample is followed by a maize succession crop. The level of succession is 21% higher than the 38% average level for the state. Aggregate input costs, including an annual land charge, are 1% higher at $676 compared with the state's statistical bureau, IMEA, estimates (Table 1). Soybean yields are about 4% higher, while prices received are about 10% lower. Thus overall the Reference farmer operational characteristics, costs, and prices, while not perfectly matched to the official state estimates, compare well to the official statistical averages for the state.

Clearly though caution should be employed as to the generalizability of the Reference data. Our challenge is that we need to understand the phenomenon of tropical intensification, and data are limited. The Reference data provide, to our knowledge, the best data available to date on the new fast growing class, the tropical commercial-scale grain farmer.

The data collected in Mato Grosso are recorded in the local currency. We convert all costs and prices to U.S. dollars based on the U.S. Federal Reserve Bank's daily average exchange rate for the years 2007–2012. Cropland harvested is the area planted for soybean and maize by each farmer. Cropland prices are the cost of land, reported by farm owners to the Reference Project, and measured in Brazilian Reals per hectares. By definition farmers' second crop maize (safrinha) land use is always less than or equal to the soybean cropland harvested. The Reference Project allocates total annual land costs across soybean and maize budgets based on the percentage of total cropped hectares each comprises.

Labor and wages include expenses related to annual hired labor. Farmers do not report unpaid labor costs. To calculate the number of workers per farm, the labor cost per farm was divided by the annual labor wage per worker for the state of Mato Grosso provided by IBGE (Instituto Brasileiro de Geografia e Estatística) for the years 2007–2012. The Reference Project allocates total annual labor costs across soybean and maize budgets based on the percentage of total cropped hectares each comprises.

Fertilizer is the amount of major inorganic nutrients annually applied to production, measured in metric tons per hectare. The fertilizer expense includes nitrogen, phosphorous, and potash. Farmers report the unit price per metric ton, application rate per hectare, and cost per hectare. These are then converted to fertilizer cost per farm for the TFP analysis.

Only 14% of the farmers report soil correctives (limestone) and pricing data were highly variable. Limestone accounts for less than 1% of the cost of production on those farms. It is an inexpensive input and it is applied every four to five years, thus there are a high number of missing values. Soil correctives were dropped from the cost of production.

Seed is measured in metric tons. Farmers report the seed cost per hectare, which is then converted to seed cost per farm for the TFP analysis. Aprosoja provided fixed seeding rates for soybean (0.05 mt/ha) and maize (0.04 mt/ha) production, which were used to calculate the price per metric ton of seed using the seed cost per hectare.

Pesticide is measured in liters. Farmers report the pesticide costs per hectare, which is then converted to cost per farm for the TFP analysis. To determine the amount of pesticide used per farm, the pesticide cost per farm was divided by the annual pesticide price per liter for the state of Mato Grosso provided by CONAB (2007–2012).

Across the entire panel, and across both crops, 13% of purchases involve complete input packages, where farmers pay one price per hectare for seed, fertilizer and pesticides. The cost was allocated to seed, fertilizer, and pesticide cost categories based on the average share costs from the other Reference Project farms.

Diesel is measured in liters. Diesel costs were provided on a per hectare basis. The diesel cost per farm was divided by the annual diesel price per liter for the state of Mato Grosso reported by ANP (Agência Nacional do Petróleo), for the years 2007–2012.

The quantity of machinery is the number of tractors, seeders, sprayers, and combines per farm. Machine expenses include only depreciation expenses in order to more accurately estimate the changes in machinery capital utilization in the TFP analysis. Reference Project farmers provide total depreciation costs on a per hectare basis. The machinery depreciation cost for each soybean and maize farm was estimated based on the value of equipment when farmers first joined the project and then follow the farmer's own depreciation schedule. The number of machines was distributed to each crop based on the cropland share percentage. Publically available pricing data on equipment types are nonexistent in Mato Grosso. For validation purposes, we compared the machinery expenses per hectare to FGV/IBRE (Fundação Getulio Vargas – Instituto Brasileiro de Economia) tractor prices per hectare for the years 2007–2012.

Results and Discussion

Descriptive statistics

Between 2007 and 2012, total production of soybean increased from 4,776 tons to 5,258 tons, averaging a 1% growth rate per year for the Reference Project farms. Total maize production increased from 2,811 tons to 4,140 tons, with an average annual growth rate of 13% (Table 2). This rapid increase in maize production results from the maize planted area growing at an annual rate of 8% per year from 2007–2012. The average soybean price growth rate equals 7% compared to maize at – 3% for the 2007–2012 period. Gross revenue per farm increased at an average annual growth rate of 8%.

Table 2: Soybean, maize, and succession crop production – average annual growth rates, 2007–2012

Variables	Unit	Average growth rates		
		Soybean	Maize	Succession
Grain yield	(mt/ha)	– 0.02	0.04	0.02
Area planted	(ha)	0.03	0.08*	0.03
Grain production per farm	(mt)	0.01	0.13	0.06
Price per mt	(US$)	0.07	– 0.03	0.05
Gross revenue per farm	(US$)	0.08	0.09	0.08
Maize land share	(%)	–	–	0.10

*Note: Maize extensification growth rate is 8% however under the succession system maize production involves no additional hectares.

Brazil's tropical soils require high input rates and active input management, especially for fertilizers, pesticides, and machinery (Schenpf, *et al*., 2001; Goldsmith, 2008; Rada and Valdes 2012). Additionally, tropical environments, have no freeze period, and have extended periods of high moisture and constantly high temperatures. High temperatures allow for significant pest pressure and therefore require aggressive management of harmful insects, weeds, and fungi. High yield outcomes in tropical settings rarely result from fertile soils and but rather from effective input management and the use of adapted seed varieties. As a result, fertilizer and pesticide cost per hectare are higher in soybean production in the tropics compared to higher latitude regions. Reference farmer soybean fertilizer and pesticide costs average US$221 and US$159 per hectare respectively, and US$183 and US$69, respectively, for second crop maize (Table 3). Combined average expenditures on fertilizer and pesticide for both crops equals US$404 and US$228 per hectare, respectively, and together comprise 53% of the total cost of production.

The average cost per hectare of maize seed is US$115; almost double the cost of soybean seed. It is important to note that soybean is a self-pollinated crop, thus producers can save and process some of their own grain for seed, which can directly lower the cost of soybean seed, and indirectly discipline the market price for soybean seed. Labor, diesel, and machinery costs per hectares are almost 1.50 times higher for soybean production compared to maize production, but are the lowest input cost categories on a per hectare basis.

The average cost difference of inputs per soybean hectare is US$130, or 19%, more in soybean production, than for maize, but gross revenue per hectare is about 1.50 times greater for soybean. Thus producers correctly focus greater input resources on the soybean crop, and limit inputs to the maize crop. This relationship differs from the Midwest U.S. where producers expend 28% more on the maize crop than soybean (Montesdeoca and Goldsmith, 2013).

On average the net return per hectare for soybean is US$401, an estimated 2.50 greater net return than maize, which averages US$160 per hectare. Maize as a lower-valued crop receives a grain price of US$127 per metric ton, almost 40% of the soybean price, which averages US $331 per metric ton for the Reference farmers. Maize yields relatively poorly in the tropical setting of Mato Grosso. Average maize yield for the Reference farmers is 40% more than soybean yields; a ratio of 1.69:1. But the ratio in Midwest U.S. (Illinois) is 3.03:1. So Reference Project farmers face not only 35% lower maize prices, but also 50% lower maize yields compared with the United States.

Factor productivity: output growth

Soybean output increases 51% across the Reference Project farms between 2007 and 2012, or 8% per year (Table 4). Rising prices account for about 2/3rds of the increase and expanding soybean cultivation about 1/3rd, and together they compensate for a slight fall in yield.

The maize output growth exceeds soybean yield growth by increasing 66% per farm from 2007 and 2012, or 9% per year. Maize's output increase reflects a different story from soybean. Maize area planted comprises approximately

Table 3: Soybean, maize, and succession crop production average costs per hectare, 2007–2012

Variables	Unit	Average cost per hectare		
		Soybean	Maize	Succession
Land	(US$/ha)	77.83	47.29	125.12
Labor	(US$/ha)	48.32	29.73	78.04
Fertilizer	(US$/ha)	221.36	182.55	403.90
Seed	(US$/ha)	56.37	115.17	171.53
Pesticide	(US$/ha)	159.24	68.90	228.14
Diesel	(US$/ha)	43.99	28.21	72.19
Machine	(US$/ha)	53.36	34.26	87.62
Aggregate inputs	(US$/ha)	675.96	545.70	927.15
Gross revenue	(US$/ha)	1,077.18	705.70	1,414.37
Net return	(US$/ha)	401.21	160.00	487.22
Grain price	(US$/mt)	331.26	127.54	458.80
Grain yield	(mt/ha)	3.25	5.50	8.75
Area planted	(ha)	1,632.11	731.63	1,632.11

Table 4: Soybean, saize, and succession output and input usage: average annual growth rates (%), 2007–2012

Variables	Unit	Average growth rates (%)		
		Soybean	Maize	Succession
Output growth	(%)	8.00	9.00	8.00
Area planted	(ha)	3.00	8.00	3.00
No. of workers	(person)	–5.00	–4.00	–5.00
Fertilizer	(mt)	4.00	13.00	5.00
Seed	(mt)	3.00	8.00	4.00
Pesticide	(liter)	16.00	16.00	16.00
Diesel	(liter)	4.00	6.00	4.00
Machine	(machine)	10.00	15.00	11.00

2/3rds of the increase, and yield 1/3rd, while price actually fell 3%.

Output increased 53% from 2007 and 2012, or on average 8% per year when combining both crops as a succession crop production system. Producers incur negative yield growth in soybean and positive yield growth in maize. There is an interesting interplay among expanding hectares planted, yield improvement, and price across the two crop system as farmers strive to achieve overall business (output) growth. Reference Project farmers expand crop production output by increasing hectares planted of both soybean and maize. But this expansion is minimally extensive as the expanded maize hectares occur on the same land has the soybeans. This uniquely tropical form of output growth plays a major role for Brazilian farmers seeking to expand gross revenue, without opening new lands for agricultural production. Thus succession cropping and higher maize yields leads to most of the increase in output per hectare, not increased soybean yields or rising prices.

Factor productivity: input growth

Farm labor for soybean production mostly decreases over the six-year period with an average 5% decrease from 2007–2012. The number of workers for maize averages a – 4% growth rate per year. A rising annual labor wage serves as the likely cause for the slowdown in labor use on the Mato Grosso farms. Over the six-year period, the annual labor wage doubles from US$4,969 in 2007 to US$10,055 in 2012, growing at an annual rate of 14% per year.

The substitution of labor inputs occurs with the intensification of industrial inputs such as fertilizer, seed, pesticide, diesel, and machinery. Pesticide and machinery inputs have the highest overall growth rates from 2007–2012, within the safrinha cropping system, growing at 16% and 11% per year, respectively. The price for all inputs, except pesticides, has risen over the study period amplifying input intensification as a source of growth (Table 5). The average fertilizer price per metric ton for soybean production from 2007–2012 is 76% (US$513) that of the fertilizer price of maize at US$684. From 2007–2012 the average price of maize seed was 2.5 times greater, US$2,880 per metric ton, than that of soybean seed at US$1,127 per metric ton. In sum Reference farmers face relatively higher input costs and lower grain prices for maize, compared with soybean, which is only partially compensated for by maize's moderately higher yields compared with soybean.

The Tornqvist index is based on actual factor (cost) shares paid for inputs and input quantities per year. The Tornqvist index measures a 40% increase in total input use in soybean production between 2007 and 2012, while input use growth is almost twice as high in maize at 76%. High maize total input use growth results from the growth in area planted, and fertilizer, and pesticide application. The Tornqvist index for the safrinha system as a whole shows a 44% increase in inputs from 2007–2012.

Factor productivity: land use growth

Soybean area planted grew from 1,429 hectares planted in 2007 to 1,710 hectares in 2012, averaging 1,632 hectares planted per farm over the six-year period. Soybean cropland expands about 3% per year throughout the entire period (Table 4). On that same cropland, maize planted increases an average 8% per year. In general, the area of cropland planted continues to grow, driven by the increase in price of land and the need to achieve commensurate returns for the added land cost. From 2007–2012, the price of land per hectare increases at a rate of 16% per year.

Total and partial factor productivity: soybean

The growth in total soybean output is due almost entirely to increases in land under cultivation and price, as yield decreases. Soybean shows positive total factor productivity, even though land factor productivity is negative, as are pesticides and machinery (Table 6). Labor productivity dramatically rises as a reduction in labor occurs while output expands. Small amounts of soybean land expansion under cultivation and price increases compensate for the decline in yield and weak individual factor productivity.

Specifically, soybean productivity per worker increases by an average 13% per year from 2007–2012, as labor inputs decline 5% per year while output grows. Also land per soybean worker increases by about 8% per year, as land under cultivation to expands while labor declines. Output growth per metric ton of fertilizer increases by approximately 5% per year. Fertilizer productivity is dampened as the sharp rise in costs offsets the relatively low levels of fertilizer usage growth. Similarly, soybean seed factor productivity grows 5% per year, as its change in quantity used rises only 3%. Interestingly the price of seed rose 15% but its cost share changes little due to seed being a relatively small component of the soybean input bundle. There also is significant inflation among a number of the other more important inputs, such as land,

Table 5: Soybean, maize, and succession crop input prices & average annual growth rates, 2007–2012

Variables	Average growth rates			Unit	Average prices			Cost
	Soybean	Maize	Succession		Soybean	Maize	Succession	Share
	%				US$			%
Grain	7.00	–3.00	5.00	(/mt)	331	127	484	–
Land	17.00	16.00	16.00	(/ha)	78	47	124	13.00
Annual Wages*	14.00	14.00	14.00	(/person)	7,724	7,724	7,724	7.00
Fertilizer	9.00	7.00	8.00	(/mt)	513	683	1,197	33.00
Seed	15.00	11.00	12.00	(/mt)	1,127	2,879	4,006	8.00
Pesticide**	–3.00	–3.00	–3.00	(/liter)	26	26	52	24.00
Diesel***	2.00	2.00	2.00	(/liter)	1	1	72	7.00
Machine****	1.00	7.00	3.00	(/tractor/ha)	47	20	67	8.00

Note: The sources of prices are *IBGE, **CONAB, ***ANP, and ****FGV/IBRE.

labor, and fertilizer. Productivity per machine decreases by an average of 2% per year from 2007–2012. Weak machinery productivity among the sample of farmers from Mato Grosso occurs as machinery use grows faster than output. This may reflect rapid expansion of conventional machinery capital in the face of the rise in total hectares cultivated combined with a need to reduce labor costs due to rapidly rising wages. Pesticide is the second largest component of the farmer's input bundle (24%) and also achieves negative (–7%) factor productivity because the quantity used dramatically rises 16% per year on average, far outstripping soybean output growth. The decline in factor productivity occurs even as prices per liter fall (–3%). Finally, diesel, a fairly minor soybean input at 8% of total costs, saw only a 2% annual increase in price, a moderate 4% increase in quantity used, and little change in its cost share. As a result, diesel usage reflects a positive factor productivity of 4% per year.

Total and partial factor productivity: maize

The decline in maize total factor productivity over the study period results from the rapid rise in fertilizer, pesticide, and machinery input usage per farm, which outstrip yield increases that are muted by falling grain prices. Productivity per maize worker increases by 13% per year over the six-year period, as labor inputs decline 4% per year and output increases. In addition, land per worker increases by 12% per year, as land expands and labor declines. Productivity per machine decreases by an average 5% per year from 2007–2012 as maize land expands 8% per year over the period while machinery input use grows at 15% per year. Productivity per metric ton of fertilizer decreases by about 3% per year. This is due to the high annual fertilizer usage growth rate of 13% compared with the output growth of 9% per year. Maize seed factor productivity increases by 1% per year, as its input usage rises at 8% per year. The price of seed grows 11% per year but its cost share changes little because seed is a relatively smaller component among the input bundle, and there is a significant increase among a number of other important inputs, such as land, labor, and fertilizer. Pesticide productivity decreases at 10% per year because input usage increases on average 19% per year, far outstripping maize output growth. Lastly diesel, one of the smallest input categories, with a 5% cost share, sees only a 2% increase in price, a 6% increase in quantity used, and little change in its cost share. As a result, its productivity is positive by improving by 3% per year.

It is important to note the stark management differences between the soybean and maize units within the safrinha system. Higher input usage and factor productivity demonstrate the primacy of soybean production as a business unit within the safrinha system. Maize input usage, especially when removing the high cost seed (hybrid) category, is much lower in tropical settings compared with soybean. The nominally, as well as relatively high, input usage by tropical soybean managers stands in sharp contrast to soybean practices in temperate production zones. Tropical maize factor productivity is poor, showing weak management controls, at the same time maize hectares rapidly expand. Thus it appears that maize within the safrinha system is a secondary crop, and justifies the diminutive Portuguese term "safrinha." Importantly, expanded planted hectares, an extensive approach, dominates over input intensification and total factor productivity in the short run.

Decomposed output growth

The smallest source of growth in the safrinha system is from total factor productivity, with a growth rate of only 1% per year (Table 7). Thus we reject Hypothesis 1.

Table 6: Soybean and maize productivity growth rate (%) overview 2007–2012

Variables	Cost share		Input use growth rate		Input price growth rate		Productivity growth rate	
	S	M	S	M	S	M	S	M
Land	13	16	3	8	17	16	– 2*	4*
Labor	7	5	– 5	– 4	14	14	13	13
Fertilizer	33	33	4	13	9	7	5	– 3
Seed	8	13	3	8	15	11	5	1
Pesticide	24	21	16	19	– 3	– 3	– 7	– 10
Diesel	7	5	4	6	2	2	4	3
Machine	8	6	10	15	1	7	– 2	– 5

Note: Where S = soybean and M = maize; all values expressed as %.
*Input productivity is the ratio of output per unit of input. One unit of land is one hectare therefore its productivity is yield growth per hectare.

Table 7: Soybean, maize, and succession crop decomposed output growth, 2007–2012

Variables	Unit	Soybean	Maize	Maize*	Succession
TFP growth rate	(%)	2.00	– 2.00	– 2.00	1.00
Extensification growth rate	(%)	3.00	8.00	0.00*	3.00
Input intensification growth rate	(%)	6.00	10.00	18.00	7.00
Decomposed output growth rate	(%)	11.00	16.00	16.00	11.00
Extensification percentage	(%)	27.00	44.00	0.00	27.00
Input intensification percentage	(%)	73.00	56.00	100.00	64.00
TFP Percentage	(%)	18.00	ND	ND	9.00

Note: ND = not determined.
*Extensification percentage for maize is 0% even though maize extensification growth rate is 8%. Under the succession system maize production involves no additional hectares.

Maize has negative rates of growth of TFP at –2%, while soybean shows positive TFP growth at +2%. Only 9% of output growth is due to TFP. Thus the succession system diverges from global trends and employs relatively lower levels of technology, which results in little productivity improvement of the key factors of production. The low TFP growth rate though makes sense when farmers manage the second crop somewhat like a ''free good.'' They are able to expand output through a unique extensification approach where they already own or control the land on which they can expand. This relieves tropical farmers at this point in time of having to make significant capital investments in advanced agricultural technologies to achieve growth.

Farm managers continue to take the traditional approaches to grow their farm businesses, expanding land and non-land input utilization at this stage of the development of tropical agriculture and the safrinha system. Combining soybean and maize into a succession system, presents an extensification annual growth rate of 3% a year, which occurs on the soybean land. The much larger expansion (8% per year) of land for maize cultivation occurs on soybean land so is not extensive, but actually intensive, more output per unit of land. Modern commercial tropical grain farmers continue to utilize the extensification strategy as 27% of growth results from expanding the land base. Thus we reject Hypothesis 2 as tropical producers diverge from global trends where only 11% of growth results from land expansion, less than half the level from the sample.

Finally, safrinha non-land input intensification grows at 7% per year; 10% per year on the maize hectares and 6% on the soybean. So most of soybean output growth (73%) results from increased input usage, while 56% of maize growth results from intensification of inputs. As a system, 64% of succession output growth results from intensification of inputs. Thus we also reject Hypothesis 3 as intensification of inputs as a source of growth among tropical grain producers is almost five times higher than the global level of 13%.

Conclusion

The objective of this manuscript is to better understand the nature of agricultural productivity under a new tropical system of production, safrinha or succession cropping, which results in two grain crops per year. The subject provides scholars and policymakers a technical foundation by which to think about agricultural expansion in the tropics. We are able to isolate how managers utilize the various inputs comprising farm production to produce both soybean and maize. Our sample of tropical farmers shows that 64% of growth involves input intensification strategies through greater chemical input application. This makes sense as pest pressures in tropical environments are high, soil fertility is low, soil quality is poor, and substitution with biotechnology provides only limited benefits. But the environmental tradeoffs from widespread chemical use when expanding production in the tropics requires attention. Alternatively, from an agribusiness perspective the primacy of inputs when increasing output portends a strong business environment for input suppliers, especially when farmed hectares continues to increase through deployment of the safrinha technology. Technologies that can help manage the high pest loads of tropical environments while stewarding the environment will hold great value going forward.

Correspondingly our results show low levels (9%) of total factor productivity driving growth, which can be interpreted as managers preferring traditional inputs and extensification over the use of advanced technologies. For agribusiness technology suppliers the implications from such behavior are a weak demand for the newest technologies among some of the fastest growing markets in the world. Currently, tropical managers can conventionally grow their businesses through succession crop extensification and intensification using traditional chemical inputs rather than expand output employing new technology. Policy makers too should note that technology adoption among tropical farmers, some of whom are some of the largest producers in the world, appears to significantly lag temperate region farmers. But doing so does not appear to constrain their growth.

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DOI: 10.5836/ijam/2017-06-100

A comparison of production systems and identification of profit drivers for Irish suckler beef farms

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ABSTRACT

The objective of this study was to determine the effect of production system (Finishing, calf-to-slaughter; Live, calf-to-live sale; Mixed, a combination of Finishing and Live) on the profitability of suckler beef farms in Ireland and furthermore, to identify the key drivers of profitability. The financial records of 38 farms participating in a knowledge transfer programme, over a 7 year period, were used. Finishing (58.4 hectares (ha) and 119.2 livestock units (LU)) and Mixed (60.5 ha and 114.7 LU) farms had greater ($P<0.05$) size and number of livestock units than Live farms (45.0 ha and 84.4 LU). Beef live weight output per ha and gross output (GO) value per LU and per ha was greater ($P<0.05$) on Finishing farms than Mixed farms. Finishing farms had the highest ($P<0.01$) concentrate costs per ha, whereas contractor costs per LU were highest ($P<0.05$) on Mixed farms. No difference ($P>0.05$) in net margin (NM) per LU or per ha was found between production systems. Although physical output, in relation to stocking rate and beef live weight, was found to be an important driver of profitability, total costs per kg output was similarly strongly correlated with gross and net margin. Therefore, reducing the level of expenditure incurred per kg output produced is imperative to improving suckler beef farm profitability.

KEYWORDS: financial performance; net margin; profit drivers; production efficiency; suckler beef farms

1. Introduction

Ireland is the fifth largest net exporter of beef in the world, exporting 90% of the total 520,000 tonnes of carcass weight produced annually, valued at just under €2.1 billion[4]. A further 210,000 cattle, worth €162 million, are exported live (Bord Bia, 2013). This combined value of output from carcasses and live animals is predominantly generated from the progeny of the suckler beef cow herd, which comprises approximately 1.1 million of the total 2.3 million cows in Ireland (CSO, 2015a), with the remainder originating from the dairy sector. Beef production activities occur on almost 80% of Irish farms (Renwick, 2013) and accordingly, the beef sector is a primary contributor to the Irish agri-food industry accounting for 34% of total gross output (GO) value in 2014 (DAFM, 2015).

However, despite its significance to the national economy, farm family incomes are low; the National Farm Survey (Hennessy and Moran, 2016), which is part of the Farm Accountancy Data Network in the EU (European Commission, 2016), provides information on output, costs and income of Irish farms. Average suckler beef farm income (including the EU direct payments and agri-environmental scheme subsidies) was €12,904 in 2015 with income on beef finishing farms 26% higher at €16,215 (Hennessy and Moran, 2016). This compares with an average annual industrial wage in Ireland in 2013 of €35,768 (CSO, 2015b). On these farms, the EU direct payments and agri-environmental subsidies represented 102% and 95% of farm family income, respectively. The level of off-farm employment by farmer and/or spouse on suckler beef and beef finishing farms is high at 60% and 48%, respectively (Hennessy and Moran, 2015). Therefore, beef farms in Ireland are heavily reliant on EU payments, and alternative sources of income outside of the farm to support the farm family (Hennessy and Rehman, 2008; Hennessy and Moran, 2016). Ireland is not unique in this respect, with beef farming globally having low levels of profitability as a result of poor productivity, inefficient farm management and biological factors (Rakipova *et al.*, 2003; Newman and Matthews, 2007; Deblitz, 2010; Barnes, 2012). The economic sustainability of beef farms is further hindered by the high sensitivity of these systems to input and output price volatility (Mosnier *et al.*, 2009).

Improving the level of farm efficiency, such as increasing the number of calves produced per cow annually

Original submitted October 2015; revision received September 2016; accepted March 2017.
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[4] At the time of writing (September 2016), €1 was approximately equivalent to £0.86 and $US1.12.
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(Crosson and McGee, 2011) or increasing live weight gain of growing and finishing cattle (Crosson *et al.*, 2009), can improve the resilience of farm system economics by reducing production costs per kilogramme of output. Of particular relevance to Irish beef cattle production systems is the capacity to grow high yields of grass over a long growing season. Correspondingly, grass when grazed in situ is one of the cheapest sources of ruminant animal feed available being 56%, 51% and 30% of the cost of grass silage, whole crop maize silage and purchased rolled barley, respectively (Finneran *et al.*, 2012). Thus, Crosson and McGee (2015) found that beef farms with a longer grazing season were the most profitable. For this reason, ruminant livestock systems in Ireland are predominantly pasture-based with the majority of suckler beef cows calving in spring in order to coincide with the onset of seasonal grass growth.

The production system operated on beef farms influences profitability. For example, McGee *et al.* (2014) showed that suckler calf-to-beef systems were more profitable than selling earlier in the animals' lifetime. Similarly, Crosson and McGee (2015) found systems finishing their own progeny were more profitable than systems selling progeny for further feeding directly after weaning. Furthermore, this study found differences within calf-to-beef finishing systems concluding that finishing male progeny as bulls, compared to steers, resulted in a higher net margin.

Recent research examining Irish beef farm profitability (Finneran and Crosson, 2013) benchmarked farms in terms of financial performance per livestock unit (LU) and concluded that greater income was linked to reduced levels of both concentrate feed usage and overhead costs per LU. This research also found that demographics such as farmer age and level of off-farm employment did not differ between the top and bottom third of farms. However, this study included both suckler beef and non-suckler beef farms and therefore, did not permit a comparison of trading options and profit drivers within suckler beef systems. Furthermore, a detailed interrogation of factors affecting the profitability of suckler beef systems was not possible. This is as a result of using FADN data (European Commission, 2016), which is a representative dataset of national performance and therefore includes farms which have non-farm sources of income and therefore, maximising profitability is often not the single or primary driver of all production decisions. Thus, the present study aims to overcome this limitation by using a group of farms that are participating in a knowledge transfer programme and are therefore, focused on profit maximisation through improving technical efficiency and animal performance.

Therefore, the objectives of this study were, for suckler beef farms in Ireland which are focussed on maximising profitability, 1) to determine if differences in profitability exist across different production systems, and, 2) identify, and quantify, the main profit drivers on these farms.

2. Materials and methods

A minimum of 3 years financial records were collected from each of 38 suckler beef farms over a 7-year period (2008–2014). All farms participated in a knowledge transfer programme, the Teagasc/Irish Farmers Journal *Business, Environment and Technology through Training, Extension and Research* (BETTER) farm beef programme (Teagasc, 2015). Farms participating in the programme received intensive advisory support in three key areas of farm operation; 1) grassland and animal nutrition management, 2) animal husbandry with specific reference to cow reproductive performance and progeny live weight performance, and, 3) business management with a particular focus on record keeping and farm planning. However, this study is not an analysis of the effectiveness of this knowledge transfer programme since records, where available, for years prior to or following farms' participation were included in the analysis.

Farms were categorised into one of three groups of production systems based on the type of animal sales within a year; Finishing (suckler calf-to-beef, selling progeny directly to commercial abattoirs for slaughter), Live (suckler calf-to-live sale, selling progeny post-weaning to the live market) or Mixed (a combination of both Live and Finishing). Assignment of farms to a specific category was based on the criteria that within a year, a farm sells at least 75% of its animals for slaughter or live sale to be categorised as Finishing or Live, respectively, otherwise the farm was categorised as Mixed. This resulted in the total number of observations over the 7-year period (2008–2014) for Finishing, Live and Mixed farms being 49, 85 and 93, respectively (Table 1).

Data were recorded by each farmer's local extension advisor using the Teagasc eProfit Monitor software (Teagasc, 2016a). The Teagasc eProfit Monitor is an online farm financial analysis tool used to record all farm inputs and outputs during a single production year. Physical farm measures included farm size, livestock numbers, production type, stocking rate and beef output. Financial measures included value of sales and purchases of livestock, variable and fixed costs. Variable costs included: concentrate feedstuff, fertiliser, contractor, veterinary and other (purchased forage, transport, straw, levies and miscellaneous items). Fixed costs included: machinery repairs, lease and running expenses, utility expenses, casual labour and bank loans and interest charges. Building and machinery depreciation were included under fixed costs and were calculated using 5% and 10% straight line depreciation, respectively. Practically all the farms (37 out of 39) in the dataset comprised of almost entirely owned, rather than leased, land. Therefore, in order to facilitate comparative analysis, it was assumed that the two predominantly leased farms were also owned and thus, leased land charges were excluded. Farmers' own labour has been omitted from the study due to an absence of records in relation to hours worked, or number

Table 1: Number of farms within each system by year

Year	System			Total
	Finishing	Live	Mixed	
2008	3	9	14	26
2009	1	13	13	27
2010	5	15	14	34
2011	7	13	18	38
2012	9	13	15	37
2013	11	11	14	36
2014	13	11	5	29
Total	49	85	93	227

of family labour units on the farm. Therefore, net margin generated on these farms is, in effect, a return for owned land and own labour. This is an approach used previously (Hennessy and Moran, 2016; Teagasc, 2016b).

All prices were corrected for yearly inflation according to the CSO price index (CSO, 2015c) using 2014 as the base year to more accurately reflect technical farm performance (Table 2). Key commodities such as cattle and beef price, fertiliser price, veterinary expenses and concentrate feed price were corrected for inflation using category specific inflation indices. All other input expenses were corrected for inflation using the general agricultural input category (Table 2). For benchmarking purposes, data was calculated per hectare (ha) and per LU (1 suckler cow = 0.9 LU) for each farm.

Statistical analysis

Model assumptions (constant variance and normal distribution) were checked using residual diagnostics. Where appropriate, log transformation was used to correct for skew and non-constant variance. Variables log transformed included concentrates per ha, per LU and as a percentage of GO, fertiliser as a percentage of GO, veterinary costs per ha and other variable costs per ha and as a percentage of GO. Means from the log scale analysis were back-transformed as medians on the data scale. As the log scale standard error could not be straightforwardly back-transformed, 95% confidence limits were produced on the log scale and the end-points were back-transformed to produce asymmetric confidence intervals on the data scale. There were few outliers and they were checked both before and after transformation in the case of variables that were log-transformed. If an outlier was determined to be influential then the analysis was repeated with and without the outlier. There was only one instance of a change in the overall conclusion where, for veterinary costs as a percentage of gross output, the result went from a tendency to significant and there was no change in which systems means were significantly different to each other. Log transformations and outlier checking resulted in acceptable residual plots in all cases. A repeated measures model was fitted to model production system with adjustment for year to allow for changes in conditions from one year to the next using the GLIMMIX procedure in SAS 9.4 (SAS, 2014). Means for production system were compared pairwise using Tukey adjustment. Statistical significance was determined as $P<0.05$ and a reported tendency as $P<0.10$. Using the CORR procedure in SAS 9.4, Pearson residuals were calculated within production system and cost variables were transformed as appropriate. A correlation of less than 0.30 was classified as 'weak', 0.30 to 0.69 as 'moderate' and 0.70 and greater as 'strong'.

3. Results

Physical and financial output

Table 3 outlines the system differences in physical farm factors, live weight output and value of output produced. There was no difference ($P>0.05$) between systems in suckler cow numbers and stocking rate, while farm size and number of LU were greater ($P<0.05$) for Finishing and Mixed farms than Live farms. Live weight output per LU showed a tendency ($P=0.064$) to be higher on Finishing farms than Live and Mixed farms. Live weight output per ha and value of output produced per LU and per ha was higher ($P<0.05$) for Finishing farms than Live and Mixed farms.

Production costs and margins

Table 4 shows differences in costs and margins across system per LU and per ha. Contractor costs per LU were

Table 2: Market inflation of cattle/beef price, fertiliser price, veterinary price, concentrate feed price and agricultural commodity input price from 2008-2014 in relation to the base year (2014=1.0) (CSO, 2015c)

	2008	2009	2010	2011	2012	2013	2014
Cattle/beef	0.87	0.78	0.79	0.96	1.08	1.1	1
Fertiliser	1.14	0.92	0.82	1.01	1.04	1.04	1
Veterinary	0.95	0.97	0.98	0.97	0.98	0.98	1
Concentrate	0.95	0.83	0.82	0.95	1.02	1.11	1
Input[1]	0.96	0.88	0.87	0.97	1.02	1.05	1

[1] Agricultural commodity input price.

Table 3: System comparisons of suckler cow numbers, farm size, number of livestock units (LU), stocking rate, and live weight output and gross output value on a per LU and per ha basis

		System (S)				
		Finishing	Live	Mixed	s.e.	P-value
Suckler cows (head)		62.1	56.3	66.2	5.40	NS
Farm size (ha)		58.4[a]	45.0[b]	60.5[a]	4.41	*
Livestock units (LU)		119.2[a]	84.4[b]	114.7[a]	9.35	*
Stocking rate (LU/ha)		2.03	1.91	1.90	0.06	NS
Live weight output	(kg/LU)	349	316	328	9.1	0.064
	(kg/ha)	713[a]	605[b]	627[b]	29.4	*
Gross output value	(€/LU)	899[a]	801[b]	803[b]	24.3	*
	(€/ha)	1561[a]	1292[b]	1294[b]	66.5	*

[a-b] Rows with common superscripts do not differ ($P>0.05$).

Table 4: Comparison of cost categories and gross and net margin per hectare (€/ha) and per livestock unit (€/LU) for Finishing, Live and Mixed farms

	Costs	Finishing	Live	Mixed	s.e.	P-value
€/LU	Concentrate^	129[2]	122[3]	114[4]	–[1]	NS
	Fertiliser	84	91	83	3.9	NS
	Contractor	60[ab]	51[b]	62[a]	3.9	*
	Veterinary	50	55	50	2.8	NS
	Other variable	91	80	82	5.2	NS
	Total variable	440	425	431	17.3	NS
	Total fixed	215	206	220	13.4	NS
	Total	646	627	652	17.5	NS
	Gross Margin	462	383	372	33.2	NS
	Net Margin	248	176	160	34.6	NS
€/ha	Concentrate^	309[a,5]	182[b,6]	193[b,7]	–[1]	**
	Fertiliser	169	174	153	10.7	NS
	Contractor	115	112	101	13.2	NS
	Veterinary^	80[8]	104[9]	84[10]	–[1]	NS
	Other variable^	152[11]	142[12]	130[13]	–[1]	NS
	Total variable	924	789	748	57.1	NS
	Total fixed	385	375	390	44.2	NS
	Total	1311	1161	1137	68.2	NS
	Gross Margin	637	501	543	51.6	NS
	Net Margin	252	127	155	67.4	NS

[a-b] Rows with common superscripts do not differ ($P>0.05$).^ Variables log-transformed.
[1] No SE but lower and upper 95% confidence limits as follows: [2]105, 157; [3]104, 142; [4]99, 132; [5]242, 393; [6]149, 223; [7]161, 232; [8]64, 101; [9]86, 126; [10]70, 99; [11]124, 186; [12]120, 168; [13]112, 151.

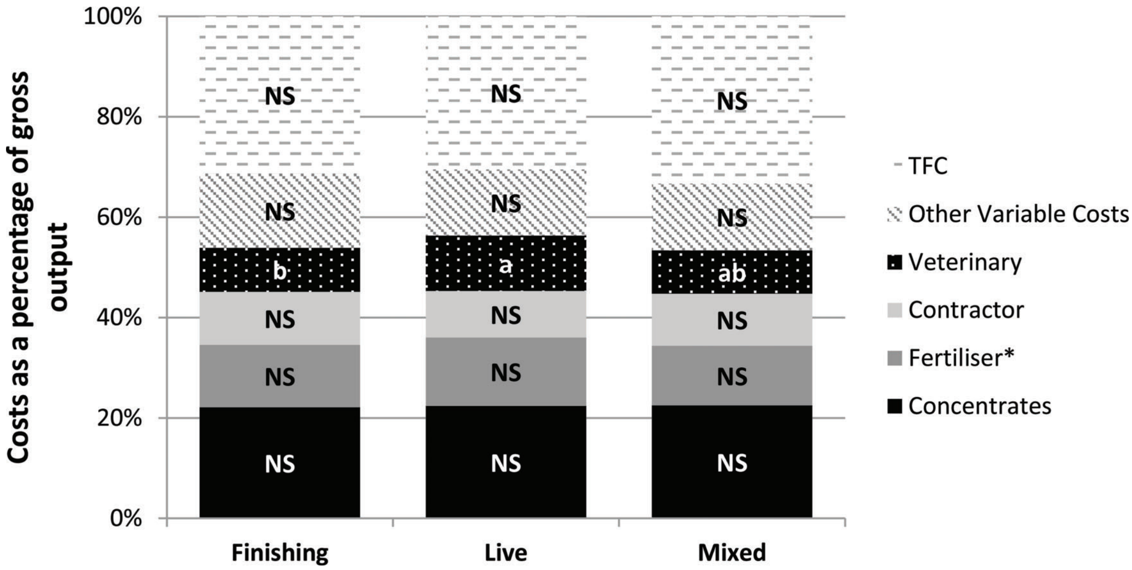

Figure 1: System analysis of components of total costs expressed as a percentage of gross output value.
[a-b] Rows with common superscripts do not differ ($P>0.05$).
* Fertiliser costs – tendency for Live farms to be greater than Finishing and Mixed farms ($P=0.051$).

higher ($P<0.05$) on Mixed farms than Live farms. Finishing farms had higher ($P<0.01$) concentrate costs per ha than Live and Mixed farms. No significant differences ($P>0.05$) were found between systems for all other variables. No differences ($P>0.05$) were observed between systems for gross margin (GM) or net margin (NM) expressed per LU or per ha basis.

Figure 1 shows differences in costs as a percentage of GO across systems. Veterinary costs as a percentage of GO were found to be greater on Live farms ($P<0.05$) than Finishing and Mixed farms. No other significant differences between costs as a percentage of GO were found ($P>0.05$) across systems, however in relation to fertiliser costs as a percentage of GO ($P=0.051$) there was a tendency for Live farms to be greater than Finishing and Mixed farms.

Correlation analysis

Relationship between output measures and gross and net margin

Table 5 highlights the relationships among farm size, stocking rate, beef live weight output and GO with GM and NM expressed on a per LU and per ha basis within Finishing, Live and Mixed farms. For all systems GO per LU and ha was significantly correlated with GM and NM per LU and ha. On Finishing farms, GM and NM per ha were also significantly, positively correlated with stocking rate and beef live weight output per ha.

Table 5: Pearson correlation analysis of farm size, stocking rate, beef live weight output and gross output with gross margin and net margin per LU and per ha within Finishing, Live and Mixed systems

			Farm Size (ha)	Stocking rate (LU/ha)	Beef live weight output (kg)		Gross output (€)	
					LU	ha	LU	ha
Finishing	Gross Margin	€/LU	-0.07 (NS)	0.01 (NS)	0.10 (NS)	0.11 (NS)	0.90***	0.46***
		€/ha	-0.10 (NS)	0.35*	0.24 (NS)	0.41**	0.39**	0.52***
	Net Margin	€/LU	-0.05 (NS)	0.02 (NS)	0.09 (NS)	0.12 (NS)	0.81***	0.44**
		€/ha	0.23 (NS)	0.46***	0.17 (NS)	0.41**	0.42**	0.61***
Live	Gross Margin	€/LU	-0.03 (NS)	-0.16 (NS)	0.47***	0.20 (NS)	0.88***	0.40***
		€/ha	0.03 (NS)	0.15 (NS)	0.55***	0.48***	0.48***	0.66***
	Net Margin	€/LU	-0.06 (NS)	-0.15 (NS)	0.53***	0.26*	0.80***	0.49***
		€/ha	0.25*	0.01 (NS)	0.43***	0.30**	0.42***	0.53***
Mixed	Gross Margin	€/LU	0.06 (NS)	0.18 (NS)	0.25*	0.28**	0.76***	0.44***
		€/ha	0.34***	0.39***	0.23*	0.38***	0.31**	0.54***
	Net Margin	€/LU	0.08 (NS)	0.12 (NS)	0.16 (NS)	0.17 (NS)	0.68***	0.40***
		€/ha	0.29**	0.38***	0.16 (NS)	0.36***	0.27**	0.53***

On Live farms, NM per ha showed a significant, positive correlation with farm size. All measures of GM and NM were positively correlated with all measures of beef live weight output with the exception of GM per LU which was not correlated with beef live weight output per ha.

On Mixed farms, GM per LU and per ha was significantly, positively correlated with all measure of beef live weight output. GM per ha was also positively correlated with farm size and stocking rate. NM per LU was positively correlated with all variables except beef live weight per LU.

Relationship among cost categories and farm output and net margin

On Finishing farms, farm size was significantly, positively correlated with concentrate costs per LU and negatively correlated with contractor costs, veterinary costs, other variable costs and fixed costs per ha (Table 6). Stocking rate was positively correlated with concentrate, fertiliser and veterinary costs per ha. Beef live weight output per LU was positively correlated with contractor and veterinary costs per ha while beef live weight output per ha was correlated with concentrate, contractor, veterinary and other variable costs per ha. GO per LU was correlated with fertiliser costs per ha and contractor costs per LU. GO per ha showed a significant, positive correlation with all cost categories per ha except fixed costs. NM per LU was negatively correlated with all cost categories per LU except other variable costs while NM per ha was negatively correlated with fixed costs per ha.

Within Live farms, farm size was significantly, negatively correlated with all cost categories on a per ha basis except other variable costs (Table 7). Stocking rate was negatively correlated with concentrate costs per LU and positively correlated with concentrate, fertiliser, veterinary and fixed costs per ha. Beef live weight output and GO per ha was positively correlated with concentrate, fertiliser and veterinary costs per ha. GO per LU was positively correlated with fertiliser and fixed costs per LU and negatively correlated with concentrate and fertiliser costs per ha. NM per LU showed negative correlations with fertiliser costs per ha and veterinary costs per LU, while NM per ha was negatively correlated with concentrate, other variable and fixed costs per ha.

On Mixed farms, farm size was negatively correlated with fertiliser costs per ha (Table 8). Stocking rate was positively correlated with all cost categories per ha except fixed costs. Beef live weight output per LU was correlated with concentrate costs per ha and contractor costs per LU, while beef live weight output and GO per ha was positively correlated with all cost categories per ha except fixed costs. GO per LU was correlated with concentrate, fertiliser and other variable costs per LU and on a per ha basis, with other variable costs. NM per LU showed negative correlations with contractor and fixed costs per LU and other variable costs per ha, while NM per ha was negatively correlated with fixed costs per ha.

Table 9 shows the correlations between costs as a percentage of GO and total costs (TC) of production per kg output with GM and NM per LU and per ha across Finishing, Live and Mixed farms. All relationships were negatively correlated. On Finishing farms, GM per LU was significantly correlated with all cost categories except total costs per kg output. GM per ha was correlated with fertiliser, contractor, veterinary and other variable costs as a percentage of GO. NM per LU was correlated with all cost categories, while NM per ha was correlated with fertiliser, contractor and veterinary costs as a percentage of GO.

In the context of Live farms, GM per LU was correlated with all cost categories except fixed costs. GM and NM per ha was correlated with fertiliser, other variable and fixed costs as a percentage of GO as well as TC per kg output. NM per LU was correlated with all cost categories.

On Mixed farms, GM and NM per LU were correlated with all cost categories. GM per ha was correlated with all cost categories except concentrates as a percentage of gross output while NM per ha was correlated with all cost categories except concentrate and contractor costs as a percentage of gross output.

4. Discussion

Given the low levels of profitability on Irish suckler beef farms, the aim of this study was to use the financial and technical records pertaining to a group of 38 suckler beef farms who were known to be commercially motivated in order to determine if production system has an effect on farm profitability. Furthermore, using these detailed financial records, a second aim was to identify key drivers of profitability within the various suckler beef production systems.

Table 6: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Finishing farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.33*	-0.05 (NS)	0.05 (NS)	-0.13 (NS)	0.05 (NS)	-0.58***	0.24 (NS)	-0.30*	0.12 (NS)	-0.35*	-0.04 (NS)	-0.42**
Stocking rate (LU/ha)		0.16 (NS)	0.40**	-0.13 (NS)	0.48***	-0.14 (NS)	0.24 (NS)	-0.13 (NS)	0.44**	-0.09 (NS)	0.25 (NS)	-0.06 (NS)	-0.11 (NS)
Beef live weight output	kg/LU	-0.10 (NS)	0.18 (NS)	-0.04 (NS)	-0.05 (NS)	-0.07 (NS)	0.31*	-0.05 (NS)	0.35*	-0.09 (NS)	0.21 (NS)	0.01 (NS)	0.12 (NS)
	kg/ha	-0.01 (NS)	0.38**	-0.13 (NS)	0.26 (NS)	-0.12 (NS)	0.39**	-0.10 (NS)	0.51***	-0.11 (NS)	0.31*	-0.05 (NS)	0.02 (NS)
Gross output	€/LU	-0.16 (NS)	0.13 (NS)	-0.08 (NS)	0.34*	-0.34***	-0.13 (NS)	-0.01 (NS)	0.26 (NS)	-0.06 (NS)	0.23 (NS)	0.05 (NS)	-0.01 (NS)
	€/ha	-0.10 (NS)	0.56***	-0.28 (NS)	0.51***	-0.17 (NS)	0.41**	-0.14 (NS)	0.64***	-0.18 (NS)	0.32*	-0.05 (NS)	-0.08 (NS)
Net Margin	€/LU	-0.49***	0.19 (NS)	-0.50***	0.26 (NS)	-0.52***	0.02 (NS)	-0.33*	0.17 (NS)	-0.21 (NS)	0.29 (NS)	-0.39**	0.03 (NS)
	€/ha	0.13 (NS)	0.08 (NS)	-0.22 (NS)	0.22 (NS)	-0.26 (NS)	-0.21 (NS)	-0.05 (NS)	0.16 (NS)	-0.06 (NS)	-0.10 (NS)	-0.02 (NS)	-0.33*

Table 7: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Live farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.03 (NS)	-0.27*	0.21 (NS)	-0.22*	-0.05 (NS)	-0.24*	0.10 (NS)	-0.23*	0.12 (NS)	-0.11 (NS)	0.06 (NS)	-0.41***
Stocking rate (LU/ha)		-0.26*	0.48***	-0.21 (NS)	0.71***	-0.00 (NS)	0.18 (NS)	0.15 (NS)	0.45***	0.01 (NS)	0.18 (NS)	-0.04 (NS)	0.22*
Beef live weight output	kg/LU	0.01 (NS)	0.00 (NS)	0.11 (NS)	-0.01 (NS)	-0.08 (NS)	-0.12 (NS)	-0.04 (NS)	0.01 (NS)	-0.07 (NS)	0.06 (NS)	-0.09 (NS)	0.06 (NS)
	kg/ha	-0.15 (NS)	0.32**	-0.06 (NS)	0.46***	-0.05 (NS)	0.02 (NS)	0.07 (NS)	0.31**	-0.04 (NS)	0.17 (NS)	-0.12 (NS)	0.20 (NS)
Gross output	€/LU	0.18 (NS)	-0.22*	0.28**	-0.33**	-0.13 (NS)	-0.17 (NS)	0.01 (NS)	-0.11 (NS)	0.10 (NS)	0.19 (NS)	0.26*	-0.02 (NS)
	€/ha	-0.15 (NS)	0.34**	-0.06 (NS)	0.49***	-0.13 (NS)	0.09 (NS)	0.10 (NS)	0.47***	0.00 (NS)	0.13 (NS)	-0.09 (NS)	0.07 (NS)
Net Margin	€/LU	-0.16 (NS)	-0.04 (NS)	-0.14 (NS)	-0.23*	-0.21 (NS)	-0.07 (NS)	-0.27*	-0.05 (NS)	-0.09 (NS)	0.10 (NS)	-0.13 (NS)	0.03 (NS)
	€/ha	0.05 (NS)	-0.30**	0.07 (NS)	-0.20 (NS)	-0.02 (NS)	-0.20 (NS)	0.17 (NS)	-0.05 (NS)	-0.07 (NS)	-0.28*	-0.07 (NS)	-0.52***

ISSN 2047-3710

Table 8: Pearson correlation analysis of farm size, stocking rate, beef live weight output, gross output and net margin with costs (€) on a per LU and per ha basis on Mixed farms

		Cost categories											
		Concentrate		Fertiliser		Contractor		Veterinary		Other variable		Fixed	
		LU	ha	LU	ha	LU	ha	LU	ha	LU	ha	LU	ha
Farm size (ha)		0.18 (NS)	-0.04 (NS)	0.14 (NS)	-0.22*	-0.02 (NS)	-0.10 (NS)	0.07 (NS)	-0.17 (NS)	0.02 (NS)	-0.01 (NS)	-0.03 (NS)	-0.01 (NS)
Stocking rate (LU/ha)		-0.12 (NS)	0.55***	-0.17 (NS)	0.47***	-0.02 (NS)	0.31**	-0.14 (NS)	0.52***	-0.07 (NS)	0.36***	0.07 (NS)	-0.07 (NS)
Beef live weight output	kg/LU	-0.04 (NS)	0.38***	0.14 (NS)	-0.05 (NS)	-0.25*	0.12 (NS)	0.11 (NS)	0.06 (NS)	-0.04 (NS)	0.09 (NS)	0.12 (NS)	0.04 (NS)
	kg/ha	-0.12 (NS)	0.63***	-0.03 (NS)	0.33**	-0.15 (NS)	0.28**	-0.02 (NS)	0.40***	-0.06 (NS)	0.31**	0.15 (NS)	-0.05 (NS)
Gross output	€/LU	0.39***	0.06 (NS)	0.39***	-0.09 (NS)	-0.10 (NS)	0.06 (NS)	0.08 (NS)	0.01 (NS)	0.22*	0.27**	0.03 (NS)	-0.01 (NS)
	€/ha	-0.09 (NS)	0.63***	-0.05 (NS)	0.46***	-0.15 (NS)	0.31**	-0.04 (NS)	0.52***	-0.03 (NS)	0.32**	0.01 (NS)	-0.10 (NS)
Net Margin	€/LU	0.19 (NS)	0.04 (NS)	-0.06 (NS)	-0.08 (NS)	-0.34**	0.07 (NS)	-0.12 (NS)	0.08 (NS)	-0.08 (NS)	0.22*	-0.43***	0.10 (NS)
	€/ha	0.15 (NS)	0.09 (NS)	0.01 (NS)	-0.06 (NS)	0.14 (NS)	-0.02 (NS)	0.05 (NS)	-0.07 (NS)	-0.05 (NS)	-0.12 (NS)	-0.15 (NS)	-0.57***

Table 9: Correlation analysis of costs as a percentage of gross output and cost of production per kg output with gross margin and net margin on Finishing, Live and Mixed farms

			Concentrate costs	Fertiliser costs	Contractor costs	Veterinary costs	Other variable costs	Fixed costs	Total costs per kg output
Finishing	Gross Margin	€/LU	-0.75***	-0.68***	-0.68***	-0.72***	-0.61***	-0.31*	-0.23 (NS)
		€/ha	-0.07 (NS)	-0.29*	-0.41**	-0.29*	-0.45**	-0.09 (NS)	-0.12 (NS)
	Net Margin	€/LU	-0.70***	-0.77***	-0.68***	-0.67***	-0.52***	-0.62***	-0.38**
		€/ha	-0.05 (NS)	-0.39**	-0.41**	-0.29*	-0.24 (NS)	-0.16 (NS)	-0.02 (NS)
Live	Gross Margin	€/LU	-0.57***	-0.54***	-0.51***	-0.57***	-0.54***	-0.03 (NS)	-0.38***
		€/ha	-0.15 (NS)	-0.32**	-0.16 (NS)	-0.20 (NS)	-0.30**	-0.30**	-0.35**
	Net Margin	€/LU	-0.46***	-0.62***	-0.39***	-0.57***	-0.46***	-0.42***	-0.61***
		€/ha	-0.13 (NS)	-0.22*	-0.15 (NS)	-0.08 (NS)	-0.26*	-0.23*	-0.27*
Mixed	Gross Margin	€/LU	-0.58***	-0.44***	-0.61***	-0.60***	-0.53***	-0.25*	-0.44***
		€/ha	-0.09 (NS)	-0.27**	-0.25*	-0.26**	-0.30**	-0.42***	-0.34***
	Net Margin	€/LU	-0.42***	-0.51***	-0.56***	-0.48***	-0.50***	-0.67***	-0.62**
		€/ha	-0.00 (NS)	-0.23*	-0.16 (NS)	-0.21*	-0.23*	-0.25*	-0.28**

Limitations of this study

While the results outlined have identified some statistically significant differences between production systems, certain limitations to this study are acknowledged. Farms in this study were selected as participants in a national knowledge transfer programme on the basis of farm location, having a herd size greater than the national average and a willingness to adopt new farm technologies. Thus, these farms were not directly representative of the national average for all of the technical and financial variables. However, this was also an important objective since the group of farms used in this current study had a main aim to increase farm profitability. Although the results shown in this study are an average of the 7 year period, Taylor and Crosson (2016) have shown the progressive improvement in profitability on these farms over the duration of the knowledge transfer programme.

All farms operated at a relatively similar level of production, particularly in relation to stocking rate. This reflects the selective nature of participation in the BETTER farm beef programme; however, this was not of particular interest since stocking rate has previously been established as a main factor effecting profitability (Fales *et al.*, 1995; Crosson *et al.*, 2014b).

Although the small sample size in this present study, 227 observations, is likely to contribute to a lack of significant differences for many variables, Milán *et al.* (2006) carried out survey work examining structural characteristics and typology of beef farms in Spain using a sample size of 130 observations. Furthermore, although using data from the National Farm Survey (Hennessy and Moran, 2015) rather than the Teagasc eProfit Monitor Analysis (Teagasc, 2016b) could facilitate a bigger sample size, there are restrictions associated with that data. The wide range of beef cattle production systems in Ireland, in addition to the number of combination systems with other farm enterprises, creates great difficulties in extracting technical and financial information solely attached to the beef enterprise. However, the records used in this study are known to be solely related to the suckler beef enterprise thus removing any external effects and allowing clear conclusions to be established.

A further limitation is the possibility of a confound existing between production system and location for farms in this study. However, this reflects the indigenous farm system locations in Ireland, whereby farms which sell progeny live either as weanlings or at older ages are typically found in the west and farms which retain ownership through to slaughter are more typical in the east.

Farm physical factors

The selection criteria for participation in the BETTER farms beef programme resulted in a larger farm size in this study relative to the national average and thus, land area, animal numbers and stocking rate were 12.7 ha, 69 LU and 1.1 LU/ha greater, respectively, than the average Irish suckler beef farm (Hennessy and Moran, 2015).

The larger farm size of Finishing and Mixed farms compared to Live farms reflects the regional diversification of farm systems in Ireland with Live farms predominantly found in the north-western region where farm size also tends to be smaller (CSO, 2012). As a direct result of smaller farm size with Live farms, but similar stocking rates, lower number of LU on Live farms is not surprising when compared to Finishing and Mixed farms. However, despite the differences noted in terms of farm size across system in this study, the correlation analysis suggests that farm size only had a small contributing factor on NM per ha. This is in agreement with (Veysset *et al.*, 2015), who found that increasing farm size did not produce economies of scale within beef systems but, in fact, resulted in increased fixed costs due to the need for further infrastructure and mechanisation. Furthermore, the negative impact of fixed costs in relation to net margin across all systems concurs with Finneran and Crosson (2013). This suggests that capital invested in farm infrastructure in order to increase farm size and production level was not justified by the additional gross output generated however further information as to the type of infrastructure purchased is required to fully justify this.

The correlation between stocking rate and concentrate costs per ha is supported by Finneran and Crosson (2013) who concluded that increasing stocking rate incurs additional expenditure and hence impedes profitability. In pasture based suckler beef systems it is important that stocking rate increases are supported by higher levels of grass utilisation rather than concentrate feeds owing to differences in feed costs. For example, in a systems modelling study Clarke and Crosson (2012), found that where increases in stocking rate are facilitated by higher quantities of grazed grass, although fertiliser costs increase, the additional carcass output produced had a positive effect on farm profitability. Due to differences in cost relativities, the additional concentrate costs incurred as a result of increased stocking rate would require a much greater increase in beef live weight output and GO, to result in greater profitability.

Considering calf-to-beef systems have been found to generate higher live weight output per ha than calf-to-weanling/store systems nationally (Teagasc, 2016b), it is unsurprising that similar results are found in the present study with Finishing farms obtaining higher live weight per ha that Live and Mixed systems. This is largely due to the relative inefficiencies of the suckler cow-calf phase, such as increased risk of disease and illness in young animals (More *et al.*, 2010) in addition to the unproductive maintenance costs of biologically inefficient beef cows (Crosson and McGee, 2012; Diskin and Kenny, 2014). However, on Finishing farms these inefficiencies are offset by the weanling-to-finish phase. While steer and heifer systems were found on many farms in this study, Finishing farms largely slaughtered male progeny as bulls. It has been shown that bulls achieve a higher live weight gain than steers (O'Riordan *et al.*, 2011; McMenamin *et al.*, 2015) and thus this may have further contributed to the higher live weight output produced on Finishing farms in this study. In addition to the higher beef live weight output, a higher price per kilogram was achieved by Finishing farms (2% and 5% greater than Live and Mixed farms, respectively) thus, explaining the greater GO value.

Production costs

Considering the varying nature of beef production systems, the lack of differences between systems in most of the production costs, particularly in terms of veterinary costs, is somewhat surprising. Considering that breeding and pre-weaned animals contribute to a greater proportion of the total LUs on Live farms, and noting that calf and calving related problems impact greatly on profitability, it is surprising that veterinary costs are not greater on Live than Finishing and Mixed farms, particularly on a per LU basis. Previous research by O'Shaughnessy *et al.* (2013) reported on a subset of 16 of the same farms as were included in this present study over a 2 year period (2009-2010), and found that dystocia effected approximately 70% of the herds, whilst calf pneumonia affected approximately 63%, therefore on a per LU basis, veterinary costs would be expected to be greater on Live farms. More *et al.* (2010) reported that the occurrence of diarrhoea and pneumonia in both pre- and post-weaned calves is the second most important health risk, after Bovine Viral Diarrhoea (BVD), to Irish beef farm productivity. Calf diarrhoea has been found to impact significantly on herd profitability due to increased mortality rates, treatment costs and reduced physical performance (Gunn and Stott, 1998). Whilst these health costs are still incurred on Finishing farms, the financial impact might be expected to be diluted by the number of mature, non-breeding animals on those farms. However, due to the focus on herd health in the knowledge transfer programme a number of factors may have prevented difference among systems in this study being detected; firstly, a herd health plan was implemented on all farms resulting in the use of vaccines in particular on reproductive and young animals, in addition the time frame of this study coincides with the establishment of the Bovine Viral Diarrhoea (BVD) eradication program by Animal Health Ireland (AHI, 2016; http://animalhealthireland.ie/?page_id=220) and finally, farms were participants in the Beef Technology Adoption Programme (BTAP; a discussion group programme funded by the Irish Department of Agriculture) thus enhancing their knowledge on herd health and how to prevent disease outbreak on farm.

Despite no significant differences being found among systems in relation to fertiliser costs, the greater numerical difference between fertiliser costs per ha and stocking rate on Live farms compared to Finishing and Mixed farms is probably attributable to regional effects. With Live farms largely located in the north-western region of the country where inclement weather conditions result in longer winter housing periods, silage conservation requirements are greater. In Ireland, recommended fertiliser application rates for grass silage production are much greater than that for grazed grass production (Teagasc, 2008), and thus incur greater fertiliser costs.

Higher concentrate costs per ha on Finishing systems compared to Live and Mixed systems is likely due to the higher concentrate input associated with the finishing phase, where cattle are offered more energy dense diets in order to reach a commercially acceptable carcass fat score (Drennan and McGee, 2009; Lenehan *et al.*, 2015; Marren *et al.*, 2015). Furthermore, the prevalence of bull beef systems on Finishing farms is likely to have resulted in predominantly, or solely, concentrate-based diets being fed during the final finishing period (O'Riordan *et al.*, 2011). Feeding high concentrate diets, in comparison to concentrate supplementation of grazed pasture or grass silage, increases feed costs (Crosson *et al.*, 2014b). However, the stronger negative correlation between concentrates as a percentage of GO and both GM and NM per LU on Finishing farms compared to Live and Mixed farms suggests that maximising the proportion of an animals' lifetime diet from grazed grass prior to the finishing phase is critical (Finneran *et al.*, 2012). This is in agreement with Crosson *et al.* (2014a) who concluded that optimising the contribution of grazed grass to the lifetime intake of cattle is important for the economic sustainability of pasture-based beef production systems.

Margin analysis

The absence of a significant difference between systems in terms of GM and NM per LU and per ha is surprising. This contradicts previous research modelling profitability of various beef production systems (Crosson *et al.*, 2014b; Crosson and McGee, 2015) reporting bull and steer finishing systems more profitable than weanling systems, thus indicating that production system has an effect on beef farm profitability. However, it must be borne in mind that this previous analysis was based on specific optimal or targeted conditions within systems and this is not necessarily the case at commercial farm level. The correlation analysis, however, identified that the main drivers of profitability varied across systems. Stocking rate was found to be the most influential factor of farm margin on Finishing and Mixed farms, which is in agreement with previous authors (Clarke and Crosson, 2012; Crosson *et al.*, 2014b), while beef live weight output per LU was a primary feature of profitability on Live farms. However, the correlations noted between beef live weight output and NM on a per ha basis on Live and Mixed farms was matched by the strength of the negative correlation between TC per kg output with NM on a per LU and per ha basis on these farms. This implies that while live weight output is an important driver of profitability, minimising costs per kg output produced is essential to attaining profit on Live and Mixed farms, more so than on Finishing farms. The larger negative effect of TC per kg output on GM and NM per ha and per LU on Live and Mixed farms compared to Finishing farms suggests that the significantly greater beef live weight output generated on Finishing farms was large enough to dilute the impact an increase in total costs would have on farm profitability.

The lack of significant difference in margin between systems is likely due to the homogeneity of the farms which is a function of the selection criteria for the participating farms. Furthermore, higher concentrate costs on Finishing farms are likely to have reduced the advantage from GO to NM on these farms despite a low impact of concentrate costs on NM being found in the correlations analysis. This is in agreement with previous findings (Crosson *et al.*, 2007) reporting a negative relationship between concentrate usage and farm net margin when concentrate intake is already optimised in a blueprint system, while Hennessy *et al.* (2012) showed that feed costs are a key factor affecting profitability on Irish beef farms.

Other variable costs were only seen to have a negative impact on NM on a per ha basis among Live farms suggesting that spending on miscellaneous items and inputs such as straw for bedding did not significantly affect farm profitability on Finishing and Mixed farms.

Furthermore, the stronger correlation between GO and NM per ha compared with GO and GM per ha on

Finishing farms suggests that GO is a good indicator of overall farm profitability. In contrast, GO and GM are more highly correlated than GO and NM per ha on Live and Mixed farms. This implies that intermediate costs, or total costs per kg output, had less of an impact on Finishing farms than those in the other two systems.

5. Conclusion

This study found that although greater beef live weight per ha and GO per LU and per ha was achieved on Finishing farms, compared to Live and Mixed farms, this was offset by the higher concentrate costs incurred and thus no difference in NM was observed across systems. Furthermore, economies of scale were not found in terms of profitability as greater farm size on Finishing farms did not lead to higher farm NM per ha or LU when compared with Live and Mixed farms. Physical output was identified as the main driver of profitability across systems in terms of stocking rate and beef live weight output per LU and per ha. However, it was established that while increasing physical performance of beef cattle in terms of beef live weight output per LU and per ha was key to increasing net margin, overall farm profitability was also effected by the level of expenditure incurred. Thus, minimising total costs per kg output is important in relation to maximising farm net margin.

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Acknowledgement

The authors would like to acknowledge the financial support of the Walsh Fellowship fund for Rachel Taylor. The authors would also like to acknowledge the management team and participants of the Teagasc/Irish Farmers Journal BETTER farms beef programme and the AIM Division of the Department of Agriculture, Food and the Marine.

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DOI: 10.5836/ijam/2017-06-111

Does the Pangea model empower family farms? A case on farmland stewardship

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ABSTRACT

Land is often considered as a metaphor for power, wealth and status. This is as true in agriculture as the control and ownership of farmland are often intertwined with the notion of food security. As a result, in recent years farmland has attracted investors outside farming which often leads to speculative behaviours. With a new approach in mind, Pangea was founded in 2012 by farm owner-operator Serge Fortin and well-known Saguenay entrepreneur Charles Sirois. Their arrival on the Quebec agricultural scene garnered significant criticism from farming communities across the province. As Pangea is beginning to venture into the province of Ontario, some wonder if the model is both scalable and transferable to other economies. This case study presents the Pangea model by virtue of several interviews conducted at Pangea's head office in Montreal in early 2016. Using a political economy framework, the model's performance is evaluated and commented on. Some limitations and future research paths are also suggested.

KEYWORDS: farm management; family farms; scalability; limited partnerships

1. Introduction

Agriculture is likely one of the most subsidised and protected industries in the world, so it not surprising that farmland ownership has become a point of contention within modern society. Farmland ownership has been the subject of many headlines all over the world, including Canada. With market vitality, and given that farmland is inflation protected and can generate good returns over time, many investors have shown an acute interest in food production and farming (Lepage, 2014).

Many funds and investors have organized themselves to acquire farmland to better their returns. Many models have emerged over the years. Montreal-based Pangea claims that it has developed a new way to invest in farmland by partnering with farming families, by offering capital access and increasing farmland values. But since Pangea started operations in 2012, it has attracted tremendous criticism from farmers, farmer's unions and politicians. Tensions erupted when Pangea purchased land in several regions across the Province of Quebec which prompted public outcry. As a result of this outcry, a parliamentary commission was held in 2015 for two days in Quebec. Many questioned Pangea's intentions and accused the company of land grabbing. Some farmers, supported by the very politically influential Union des Producteurs Agricole (UPA), claimed that farmland should only be owned by farmer-operators, and that all transactions should be monitored and approved by the union representing farmers. Pangea has disputed these criticisms numerous times since its inception. The UPA is, by law, the only organization allowed to represent the interest of farmers in the province and has historically been perceived as one of the most powerful lobby groups in the province.

The aim of this case study is to determine how Pangea has affected the whole notion of farmland ownership. This case will also attempt to show how different Pangea's model is from the established farming model. The case will be considered within a political economy framework and will look at partnerships affected by power or dependence, as well as the conflicting and cooperative relationships for Pangea. While farmland management and stewardship is discussed a great deal, it is rarely theorised. This article will begin by presenting a theoretical framework applied to the political economy of farmland protection and regulation in advanced capitalist economies. It will also integrate the analysis of preventive policies across the social, environmental and economic domains.

2. Context

Ever since the 2008 dramatic surge in agricultural commodity prices, many have speculated that countries and investors are competing for land, more specifically arable farmland (Arezki, Deininger and Selod, 2012). There has been a significant increase of farmland transactions over the last few years. From 2000 to 2011, the International Land Coalition reported over 2000 transactions which involved more than 200 million hectares of land, a region

Original submitted May 2016; revision received February 2017; accepted October 2017.

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larger than the province of Quebec (MAPAQ, 2015). More than 67% of the areas involved in transactions are located in Africa (AGÉCO, 2012).

In Canada, the situation is somewhat different, but some trends can be identified. There is an increasing amount of farmland being exploited by non-traditional owners. In Québec 84% of farmland is owned by owner-operators, compared to 70.7% in Ontario. A study from the University of Guelph published in 2010 showed that most of the farmland is either rented by retired farmers or rented by local owners (Bryan, Deaton, Weersink and Meilke, 2011). Nonetheless, it has been challenging to monitor the extent of farmland transaction activity, particularly transactions involving investors coming from outside traditional farming communities (Bryan, Deaton, Weersink and Meilke, 2011).

The common underlying intent in farmland acquisition would be to secure supplies of grains by acquiring large quantities of arable land in other countries. As such, farmland protection and management has been a topical issue in both western and developing countries. Urban and suburban growth in Canada has had a significant impact upon land use, real estate speculation, property taxation and the agricultural sector of the country. As a result, farmland has been a subject of many political debates in recent years (Richetto, 1983). Farmland protection and management are relatively broad concepts. It generally involves both quantitative and qualitative protection of farmland by legal, administrative, economic and technical means and measures.

Many have argued that governments should play a more active role in farmland protection. Governments in developed countries that manage urbanizing areas are increasingly utilizing mechanisms to preserve farmland and protect local farm economies. The underlying determinant for these policies is to exercise control over increasing prices of farmland (Nickerson and Lynch, 2001).

Most of these concerns are related to developing countries. In recent years though, developed countries have also expressed similar concerns (Nickerson and Hellerstein, 2006). More specifically, urban-rural edges have been of interest over the past few years (Oberholtzer, Clancy and Esseks, 2010; Sokolow, 2010).

3. Farmland protection and values

In the developed world, the impact of farmland protection programs has been mixed. Some suggest that the criteria used for designating protected farmland is not effective (Hart, 1991; Klein and Reganold, 1997; Oberholtzer, Clancy and Esseks, 2010). Beyond urban sprawl, economic, political, and social forces greatly influence farm operations and operators in deciding whether to continue in the sector or sell out.

The values of farmland and fluctuations have been studied for decades (Lence, 2001; Sherrick, Mallory and Hopper, 2013). In the Western world, farmland value is often recognized as an effective measure and the financial strength of the agricultural sector (Zakrzewicz, Brorsen and Briggeman, 2012). Farmland price fluctuation, whether higher or lower, represents a source of concern for farmers and policymakers alike (Briggeman, Gunderson and Gloy, 2009). The value of non-agricultural characteristics of farmland has been noted in many previous studies that describe the frequently speculative nature of business transactions where the buyer intends to develop the land for other economic purposes. Buyers with a special motivation often pay more than the market price to obtain access to agricultural land (Drozd and Johnson, 2004). Bidding wars can lead to farmland prices that are not affordable to farmers with little or no access to capital.

Ferguson, Hartley and Carlberg (2006) have argued that the effects of regulation with respect to farmland purchase are negative overall, which signifies that the more stringent the regulation is to protect farmland the more likely land values will be lower. Farmland returns have been relatively strong over the last few years and many are now monitoring price progress in the sector. Its display of low systematic risk, high inflation hedging potential, and good diversification benefits make farmland an interesting investment option and as a result, there is significant interest in farmland from non-operator investors who have not been in agriculture and/or farming before (Henley, 1998). In fact, some studies suggest that farmland has been a reasonably good investment over the past few decades, particularly in Canada (Painter, 2010).

According to Sherrick, Mallory and Hopper (2013) agricultural real estate investments have outperformed other types of investment opportunities. They have recognized greater interest in farmland investing, yet the collection of data remains a challenge. No real comprehensive global database exists to monitor these activities. Still, farmland investment has attracted a lot of attention these past few years, particularly since 2008.

Economic cycles and interest rates have significant impact on farmland prices. In recent years, real farmland values have surpassed the record highs set a few decades ago when interest rates were historically high (Zakrzewicz, Brorsen and Briggeman, 2012). Similar to equity markets, farmland is exposed to boom and bust cycles. Predicting and knowing what factors affect farmland prices is key for many stakeholders in agriculture.

Canada is certainly not in the same situation as other emerging markets. China, for example, with its very large population and with little land, feeds 22% of the world's population with only 7 % of the world's farmland (Luo *et al.*, 2013). Resource scarcity is clearly a challenge in China. But in developed economies, the significance of farmland availability, and related operational costs have generated concerns over issues related to the risk exposure facing grain farmers. Risks have gone up at times, depending on financial agreements included in rental contracts (Paulson and Schnitkey, 2013).

Access to proper capital to buy farmland has also been assessed in past studies. Credit quality does not appear to be affected by the increase of farmland prices (Cocheo, 2013). Pangea co-founder Charles Sirois believes that one of the most significant challenges for small scale farmers is access to capital in order to become more productive via scale. During our interview with him, Mr. Sirois stated, "To avoid the industrialization of agriculture, the family has to make decisions. Farms should be managed by families, but it has to be sustainable. To be sustainable, it has to be profitable. So, the optimal size of a family farm should be set at 3,000 acres, we figured" (personal communication).

4. The family farm

The whole notion of the "family farm", no matter how it is defined, has also been at the core of discussions on farmland stewardship. Many believe that the changes we see in agriculture are severely threatening farms which have been owned by families for decades (Huang *et al.*, 2006). These factors have been given little, if any, consideration when designating and designing strategies to protect important agricultural lands in mature economies. Little attention has also been given to how to scale up family-owned operations in agriculture. Resources, human capital and knowledge to support a profitable agricultural enterprise are arguably as imperative as having access to high quality soils (Klein and Reganold, 1997).

The historical role of families as farm operators also needs to be underscored. As such, succession planning remains an issue in agriculture. Farmland is often abandoned or not properly utilized by communities. This often leads to discounted acquisitions, although in some countries actions have been taken that have allowed price premiums for farmland to be achieved (Hüttel, Jetzinger and Odening, 2014).

Farmland ownership transfers occur for many reasons. Over the last few years, the industrialized world has witnessed an accelerated pace in primary production consolidation, smaller operations being acquired by larger ones as families let go of assets. As a result, fewer farms are managed by families as they exit the industry. In contrast, another phenomenon has also occurred. Many investors living in urban centres have opted to invest in regions to begin hobby farms, but not for commercial purposes.

5. Pangea

Over the years, Canada has seen different farmland purchase models. Meloche and Debailleul (2013) have argued that there are three distinctive models of farmland investment mechanisms. The first model is a fund focused on buying and renting farmland. The sole purpose of these domestic funds is to increase returns for investors. Some examples are Agriterra in Quebec and Assiniboine in Saskatchewan. Another model is focused on concessions of farmland to local farmers. In this model, a domestic fund buys land for farmers and rents it to local farmers at a discounted price. The third model is based on a vertically integrated approach where many enterprise elements and intents are combined (Charlebois and Camp, 2007). In this model in order to increase their capacity farmers are supported by a financial partner. This model is particularly popular in hog production. Pangea's creation in 2012 would not fit any of the three models described above as the fundamental principle of Pangea is to create partnerships with farmers without taking away majority shares from the operator-farmer. The following comment by Mr. Sirois captures the financial philosophy behind the company: "Most financial models work with the premise of making inflation, plus 4%. Life insurance companies, pension plans, all will face gigantic problems. It's tough to get 4% in today's world, bonds, and stocks, impossible. So bankers look for alternatives, like hedge funds, real estate, and many other investments. We should invest in real assets. Why buy gold? You can't do anything with it. You can't eat it. Farmland is a good investment for the future and to hedge against uncertainty" (personal communication).

Pangea provides a long-term rate instrument that will satisfy the need of achieving a good return—the rate of inflation plus 4%. Reducing the variance is key. Farmland is inflation protected, but Pangea believes it is fairly easy to achieve 4% if the family unit operates the farm properly. Pangea is using capital to assist farm operators, and specifically, farming families.

With a new approach in mind, Pangea was founded in 2012 by farm owner-operator Serge Fortin and well-known Saguenay entrepreneur Charles Sirois. Both men were involved in highly successful telecommunication ventures. Mr. Fortin is also a multi-generation farmer. The company owns and seeks to acquire high-quality primary row crop farmland located in agricultural markets throughout Eastern Canada. The main impetus of Pangea is "to develop sustainable and profitable agricultural enterprises, to use regional players for supplies, services and expert agricultural resources, to demonstrate flexibility in the actions to be promoted to reflect the preferences of our agricultural partners, to purchase land whose agricultural yield justifies its price, to take regional differences in land into account in order to achieve its full potential, and to support agricultural partners through training, agricultural coaching and business mentoring".

Under the Pangea model, farmers remain owners of the land while entering into a limited partnership with Pangea. The majority owner (51%) is the farmer. This co-enterprise rents land from both Pangea and the farmer. Under such an agreement, farmers are compensated accordingly by the co-enterprise to maintain the land rented by the co-enterprise. This is a new ownership and partnership model in farming (Lepage, 2014). The fundamental objective of Pangea is to establish business partnerships with farmers to make underused agricultural land more productive and allow farmers to earn more money. Pangea's model postulates that small-scale farming, which dominated farming in Canada, has run its course and may not be optimal for the future. But the Pangea model does not support the industrialization of farming either, as claimed by the co-founders. "Land grabbing in Africa is awful. That's when I became interested in food production. Most were stating that the industrialization of agriculture is the only solution. On the other hand, many are saying artisanal production is more sustainable, but that's not profitable. Both were undesirable. Something was wrong" (Charles Sirois, Co-Founder of Pangea, personal communication). It is intended to empower family farms to become more profitable and thus, more sustainable.

Pangea does not consider itself an investment fund, but it is divided into three separate divisions. The first one, Pangea Terres Agricoles, acquires land for the company in diverse geographic regions to mitigate risks, such as the risk of weather by spreading farmland acquisitions geographically. This is set up as an investment trust which allows for others to invest in farmland. Main shareholders have an agreement not to sell purchased farmland for at least 50 years (Fuchs, Meyer-Eppler and Hamenstädt, 2013).

Pangea Operations, the company's second division, plays a key role in bringing together farmers and Pangea.

What Pangea proposes under Pangea Operations is a partnership with farmers by virtue of a co-enterprise. When asked about his farming partnership with Pangea, Patrice Garneau responded, ''Pangea will provide me with some advice, but they don't intervene in how I run my business'' (farmer and Pangea partner, personal communication). Co-enterprises are called Agricultural Operating Partnership (AOP), which provides dividends to both the farmer and Pangea. Pangea commits to be very transparent and flexible to the farmer-operator's needs.

The goal with AOP's is to increase operational efficiencies and apply more budgetary rigour to farming. Pangea currently has seven AOPs. These types of farming partnerships have been studied on a few occasions (Calomiris *et al.*, 1986; Collins and Bourn, 1986; Fiske *et al.*, 1986) and have had mixed results (Cheriet and Dikmen-Gorini 2014). For the time being Pangea has only considered large cereal crop production. The agricultural partner is the decision-maker and principal holder of the net profit of the joint venture. The goal in creating a co-enterprise is to address the issue of capital access. Charles Sirois stated: ''The mainstream belief is that the family farm should have 250, 300 acres. The UPA stated this as it believed that family farms were only able to handle such a scale, from a capital point of view. Since agriculture is a closed system, it was likely true. So capital is the problem'' (Co-founder of Pangea, personal communication).

As mentioned before, the majority shareholder of the co-enterprise is the farmer at 51%, which is key to the model. Pangea owns 49% of the AOP. The farmer and Pangea each own their own land but share equipment, infrastructure and managerial know-how.

Pangea Com, a third division, is dedicated to developing international markets for the company and its partners. This division has yet to be developed.

Finding the right partner has been the most significant challenge for Pangea. It first needs to find the proper region before selecting a producer who can fit and work in the context of a co-enterprise. Robin Godin Gauthier, Pangea's Agrologist, notes that, ''Finding the right partner is difficult. Finding land is not difficult, there's too much of it in fact. We're getting better at finding the right partner, but it's difficult. Most who approach us want to do business with us for the wrong reasons'' (personal communication). The region itself has to exude agrological potential and social accessibility. Criteria used to find the right partners are; entrepreneurial values and evidence of any motivation to manage a scalable operation.

The profile used by Pangea also suggests that it is actively looking for educated individuals with a good reputation in the community. Pangea also looks for individuals with strong leadership skills who can handle highly stressful situations. Quality-focused is also another personal attribute Pangea looks for: ''We need partners who are committed which is why we give them majority ownership and a lot of leverage'' (Robin Godin Gauthier, Pangea's Agrologist, personal communication). Once the right producer has been found, land is selected based on the following criteria: Proximity from the farmer-operator (maximum 30-minute tractor journey), a minimum of 100 acres per lot, possibility of upgrade and good return potential.

Farmers can continue to make decisions with Pangea on how the land will be used. In the process, they have access to lower interest rates and better lending conditions. Pangea and AOP's are currently managing more than 15,000 acres of farmland, of which 8,956 acres are owned by Pangea. The company claims to have invested over $22m in farmland, equipment, inputs and services in several regions in Quebec and Ontario to-date. Most AOP's are located in the province of Quebec (6 of 7). Pangea currently has only one partnership (AOP) in Ontario and has plans to expand in this province.

Since its foundation, Pangea has been targeted as a company which mainly intends to speculate on farmland prices, an affront to family farms (Nicolas, 2014). Some have suggested that the sole purpose of the company is to land grab farmland from domestic and/or local owners. It all began when Pangea purchased 2,400 acres from the National Bank in 2012 after the financial institution faced considerable criticism in the region. As Katy Dupéré noted ''Many believe the UPA forcefully defends small farms so their revenues as a union are not affected. [This] makes sense'' (in-house lawyer, personal communication). During our interview with Patrice Garneau stated, ''Why UPA doesn't support Pangea? I have no idea. I suspect that the UPA feels that money and greed motivate Pangea. They never asked why we got involved with Pangea, which is disappointing'' (farmer and Pangea partner, personal communication). Charles Sirois, Co-Founder of Pangea, similarly does not understand why UPA will not support Pangea: ''The whole idea of the union is to have agriculture live on welfare. With Pangea, they don't need the union anymore. I don't get why people want to subsidize poor farmers'' (personal communication).

A commission on the matter was held in 2015 to allow Members of the Quebec National Assembly (MNA) to evaluate whether land grabbing was actually occurring in the province. The commission was arguably motivated by the UPA's very public affront towards Pangea's model. Testimonies occurred in March 2015 and lasted two full days. The UPA made a formal request to be allowed to oversee all farmland transaction in the province, and to be granted authority to approve them. As a result of the commission, several MNAs, except those of the Parti Québécois, are in agreement that Pangea is unique and may be beneficial to the province's agricultural economy. Quebec's Ministry of Agriculture shared the view. When asked about the commission, Charles Sirois stated: ''The government loves the model. Regions can only grow through sectors: tourism, natural recourses and agriculture. With our model, agriculture can grow in regions'' (Co-Founder of Pangea, personal communication). Patrice Garneau's response about the commission hearing was, ''At the Commission, you could feel that most were against Pangea, without knowing what it did. But the Commission was a waste of time since Quebec is not experiencing any land grabbing'' (farmer and Pangea partner, personal communication).

At the time, the commission garnered significant media attention. Since then, the hype around Pangea has dropped significantly. The number of mentions related to Pangea and land grabbing in the media has dropped by 34% in 2015 from 2014 (Pangea, 2016). Pangea also has specific expectations when it comes to profitability. Jean-Paul Tardif, Chief Operating Officer at Pangea,

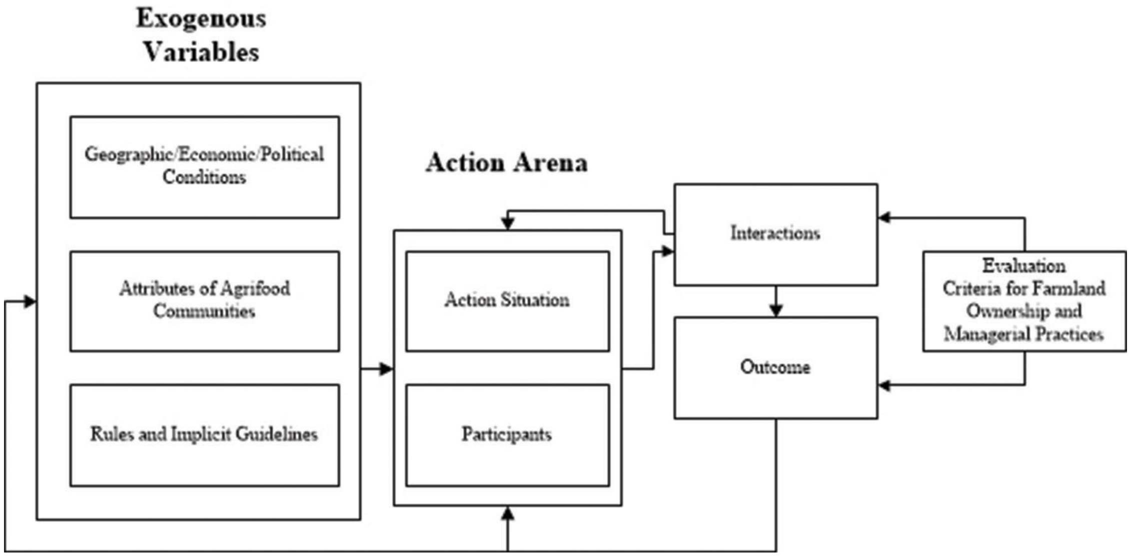

Figure 1: Political Economies of Farmland Ownership in Mature Economies

spoke about Pangea's expectations, "We expect most operations to take 3 years before they are profitable" (personal communication).

The day-to-day relationship with farmers is key for Pangea as they visit farmers on a regular basis. They encourage farmers to get in touch with them: "We encourage farmers to call us and to seek some advice. Typically, during the first year though, they like to show they know things. But after, they get more comfortable, more vulnerable with Pangea" (Jean-Paul Tardif, Chief Operating Officer, Pangea, personal communication). Patrice Garneau noted that, "Robin and Serge come often for a visit" (farmer and Pangea partner, personal communication).

The Pangea model is unique but has been scrutinized by many groups over the last few years. Pangea's vision is to allow families to stay in regions and increase the scale of their operations through a unique business partnership. Allowing partners to immerse themselves in their farming business is not easy to accept. Often, farmers are uncomfortable allowing external stakeholders to look into their affairs. Pangea also works to create camaraderie amongst the AOP's by hosting knowledge sharing events which include all family members of the AOP's.

6. Political economies of farmland ownership and management

To conceptually review Pangea's purpose, we looked at the company as a part of a political economy. It has been argued that the homogeneity of farmland and irrigation systems increased the transparency of farming, thereby increasing appropriability (Brezis and Verdier, 2014). Therein lies a deep connection between geography, topography and economics. Farmland stewardship is connected to all three intrinsic aspects of political economies. Water, essential to agriculture, has also had an impact on farmland management over the years. Irrigation led to differences in the power of the state, state institutions and political systems for centuries. This can still be true today.

To examine how agencies interact with each other in agriculture, a political economy framework is the most appropriate for proper evaluation. Political economies allow for a better understanding of how institutions, the political environment, and an economic system influence one another. Political economies consider the spatial aspects of economic activities in agriculture, and it is appropriate that they examine the location, distribution, and spatial organization of agro-economic activities. Urban centres and economies of agglomeration, as well as the effects of distances and transportation are also in the scope of such a conceptual approach (Charlebois, 2005; Boyer and Charlebois, 2007).

Land is often considered as a metaphor for power, wealth and status. In developed economies, the most common reason to impose restrictions on farmland ownership is domestic food security. For speculators, the combination of power and fast returns can be attractive. Research has shown that urban citizens are willing to acquire farmland in certain areas as long as they can expect the value of farmland to increase (Liu, 2015). This is likely why farmland is often considered an attractive investment for speculators.

From a policy perspective, it has been argued that poor legislation allows foreign investors to take advantage of low priced farmland in the western world. These claims have often no foundation since most farm prices are based on levels of productivity, or what the potential of productivity may be (Dadak, 2004). One of the primary reasons for low productivity in agriculture is the inability for many small farming operations to reach reasonable economies of scale. A good system of private property rights for farmlands is an essential ingredient of good economic development (Krasnozhon, 2013). This is often perceived as a founding premise to sound rural economic development.

The attempt to portray the institutional landscape for farmland management and ownership is represented in Figure 1. As shown in the diagram, exogenous variables affect the structure of an action arena, generating interactions that produce outcomes. Outcomes can lead to cooperative or conflicting relationships within a political economy (Walker, 2006). Evaluative criteria are used to judge the performance of the system by examining the patterns of interactions and outcomes. The focal point of the framework is called Action Arena in which participants and an action situation interact as they are affected by exogenous variables. These interactions can produce outcomes that in turn affect the participants and the action situation. Action arenas exist in local, regional, national, and international councils, in firms and markets, and in the interactions among all of these arenas with others. The farmland public discourse potentially includes all levels of society, in many different ways.

An action situation can be considered as using several clusters of variables: participants (who may be either single individuals or corporate actors), positions, potential outcomes, action-outcome linkages and cooperation amongst actors, the control or power that participants exercise, types of information generated, and the costs and benefits assigned to actions and outcomes. An action situation refers to the social space where participants with diverse preferences interact, exchange goods and services, collaborate and solve issues, dominate one another, or conflict with one another.

Outcomes feed back onto the participants and the situation and may transform both over time. Over time, outcomes may also slowly affect some of the exogenous variables. In undertaking an analysis, however, one treats the exogenous variables as fixed; at least for the purpose of the analysis. When the interactions yielding outcomes are productive for those involved, the participants may increase their commitment to maintaining the structure of the situation as it is in order to continue to receive positive outcomes. In the case of political economies, when participants view interactions as unfair or otherwise inappropriate, they may change their strategies even when they are receiving positive outcomes from the situation. When outcomes are perceived by those involved (or others) as less valued than other outcomes that might be obtained, some will raise questions about trying to change the structure of the situations by moving to a different level and changing the exogenous variables themselves. Or, if the procedures were viewed as unfair, motivation to change the structure may exist.

7. Methodology

We chose an exploratory case study design to guide our investigation based on Yin's (1994) argument that case studies are the preferred strategy when 'how' or 'why' questions are being posed and when the focus is on a modern phenomenon within a real-life context. When using the political economy framework, such an approach is particularly appropriate for understanding the details and complexity of a phenomenon and design. In our study research data was collected through multiple approaches. A semi-structured questionnaire was designed and adopted to collect primary data. The objective of the empirical segment is not to test the applicability of the existing approaches, but rather to study conceptual nuances related to the presented model grounded on the political economy framework.

A survey study focused on formal onsite interviews at Pangea's headquarters in Montreal, Canada in January 2016. Comments were recorded comprehensively for supporting analysis. Respondents were interviewed separately, and represented key informants in a variety of functional areas, including co-founders. These individuals possessed sufficient experience and understanding of the organization's culture and strategic intents to be able to comment with authority on the young history of Pangea and its role in the economy. A total of seven (7) people form the company; each was interviewed, along with one farmer who is involved in an AOP. The interview questions were largely designed to be open-ended in order to provide flexibility in interview discussions. The interviews provided information on the perceptions, application and experience of strategy in food security and biotechnology. The collected data was arranged, analysed and put into the subsequent application phase. A draft version of the paper was submitted for review to the organization for internal validity (Yin, 1994). This case study will aim to uncover best practices in land investment, management and stewardship in agriculture.

8. Findings

The value of farmland is determined by many agronomic, economic, demographic and geographic factors. These factors have affected how farmer-operators perceive their future and how they wish to mitigate their financial risks. Controlling values can also be done in many ways but threats can emerge instantly. The arrival of Pangea in Canadian agriculture made many stakeholders react. While some opposed its model, others supported it. Pangea's arrival challenged the values embedded in policies aimed at protecting family farms and the capacity for one nation to preserve food sovereignty. Pangea was perceived as an external to agriculture so political linkages were critical. Robin Godin Gauthier stated that, "We deal with a lot of politicians, their support is very important to us because our partners are affected by these relationships" (Pangea's Agrologist, personal communication).

All agricultural policy challenges are becoming international ones. External menaces are influencing domestically-based issues and can be resolved only in a network of relationships with other nations and transnational interests. Farmland ownership is often recognized as a metric for how open and vulnerable an agricultural economy is becoming. The more non-farm operators or external investors own land, the more vulnerable an agricultural economy will be perceived to be (Briggeman, Gunderson and Gloy, 2009). Provincial and federal institutions play a role in policies and policy making related to farmland management and stewardship, but the validity and the effectiveness of many state-sponsored organizations are declining. This may be the reason why trade groups and others react to insurgences. Pangea's Director of Communications, Marie-Christine Éthier stated, "The UPA's voice is very strong, so it's been a challenge. Farmers are very afraid to talk" (personal communication).

Farmland is often intertwined with the notion of power and influence in rural communities and beyond. The capacity to control and support the food security agenda for any developed economies has been influencing pundits in agriculture. Table 1 presents several factors that affected the action arena amongst agents in the political economy.

Table 1: Exogenous variables affecting the political economy of farmland governance

Exogenous variables affecting Pangea Strategy	Observations	References
Geographic conditions	• Acquisitions in rural communities to leverage wealth creation • Pangea looks for farmland in poor agrological conditions • Pangea actively looking for agrological potential • Pangea mitigates risks by acquiring farmland in many different regions, reduce variance	Klein and Reganold, 1997; Henley, 1998; Oberholtzer, Clancy and Esseks, 2010; Brezis and Verdier, 2014; Bausch, 2015.
Economic conditions	• Misunderstanding of model related to how it financially operates • Changing the inability for many small farming operations to reach reasonable economies of scale; • Increase cash flow of small operations (family farms) • Making capital intensive operations viable • Both spouses can work on the farm on a full-time basis • Pangea provides knowledge and capital to co-enterprise • Pangea model spreads variance and limits risk exposure • Pangea does not bid against another farmers to acquire farmland • Enterprise not supportive of speculative behaviour related to farmland • Pangea's model not easily expandable	Dadak, 2004; Drozd and Johnson, 2004; Huang et al., 2006; Painter, 2010; Oberholtzer, Clancy and Esseks, 2010; Arezki, Deininger and Selod, 2012; Deinenger, 2013; Krasnozhon, 2013; Weber and Key, 2015.
Political conditions	• Pangea seen as an economic intruder • Confusion about Pangea model led to political conflict • Segregation of Pangea partners from farmer union • Pangea perceived as external agent to agriculture • No state intervention required • Transparency key to Pangea approach	Richetto, 1983; Hart, 1991; Walker, 2006; Krasnozhon, 2013; Eagle et al., 2015; Liu, 2015.
Attributes of Communities	• Limited business knowledge and professionalism in rural communities • Farmers know farming, challenging for outsider to train and provide enhanced knowledge • Growth may not be a value embraced by all • Push against "financialization" of food • Legacy of farmland critical to farmers for next generation • Pangea often seen as a bankruptcy avoiding mechanism • Limited partnership concept difficult to understand by farmers • Pangea's promise hard to believe by rural communities • Farmer-partners guilty by association	Ferguson, Hartley and Carlberg, 2006; Engelen et al., 2010; Magnan, 2012; McMichael, 2012; Fuchs, Meyer-Eppler and Hamenstädt, 2013.
Rules	• Pangea not seen as member of community, no social license • Pangea's core values differ from traditional, artisanal farming • The UPA is the sole protector of farmers • Pangea depends on relationship based on trust and engage with reliable partners • Proximity of support is key	Cavailhes, Hilal and Wavresky, 2012; Eagle et al., 2015; Liu, 2015.

Geographic factors are critical to any transactions. Pangea was and is very selective in terms of where to purchase land. As Katy Dupéré, Pangea's in-house lawyer, told us "We will not buy land if it is located within 30 minutes of tractor-time of one of our current partners" (personal communication). It mitigates its risks so it does not comprise its chance to maintain a profitable portfolio: "There is a fundamental principle in mathematics. When you centralize the decision-making process, you will increase the variance, and variance is risk. By having many partnerships, the variance is significantly decreased" (Charles Sirois, Co-Founder of Pangea, personal communication).

The essence of Pangea's model is to reduce the variance, and risks by spreading its footprint into many regions. Economic factors also ought to be considered. At first, some did not understand Pangea's model. For instance, Patrice Garneau stated, "At the beginning, we weren't sure about Pangea. But after a while, we realized that they were serious" (farmer and Pangea partner, personal communication). It came as a surprise and was deemed almost too good to be true. Katy Dupéré informed us that, "My practice with Pangea is 5% related to law, but most of it is about education, counselling and support for young farmers. We're giving them a dream almost." She also stated that, "The biggest challenge for farmers is to accept to be involved at 51%. At first, they are not always convinced they can deliver. But most importantly, they are not accustomed to dealing with an external partner" (in-house lawyer, personal communication).

One clear incentive for farmers is to improve cash flow and the financial viability of their operations. For instance, Patrice Garneau explained that he contacted Pangea to partner with them: ''We were very interested in dealing with Pangea since it is more challenging to invest in cash crops without having our own parents involved. Getting Pangea involved increased our cash flow'' (personal communication). By creating a co-enterprise, farmers are able to rely on an enhanced access to capital to support their operations. Robin Godin Gauthiert noted that, ''Producers often underestimate the learning process, and Pangea helps partners to acquire business-oriented knowledge like cash flow management. But Pangea also learns from partners as well'' (Pangea's Agrologist, personal communication).

According to Garneau, the cash flow is healthy enough that it allows the farmer and partner of Pangea and his family to work on the farm on a full-time basis. This is a significant incentive for families who want to spend some time together. One aspect of Pangea's model, which remained misunderstood, or even disbelieved, was the claim that they would not outbid another farmer when purchasing farmland. What is interesting is that, despite claiming how transparent it is, Pangea does not disclose which deals they have walked away from. This may have fuelled speculations about Pangea's ulterior motives. During the commission, many members of the committee disputed Pangea's claim since it is difficult to demonstrate. However, Patrice Garneau supported Pangea's claim. During an interview he stated: ''Pangea will buy land based on its market value. If a farmer comes in with a highest bid, Pangea will not compete, and I've seen it happen.'' (farmer and Pangea partner, personal communication).

Scalability for many farmers is also a challenge. Pangea brings knowledge and expertise into the co-enterprise which was acknowledged by the Patrice Garneau: ''Cash crops were considered as bad business, for years. Pangea is allowing us to understand how we can make money with a different commodity'' (farmer and Pangea partner, personal communication).

From a model perspective, it is challenging to appreciate how it can expand beyond a dozen partnerships in Eastern Canada, if Pangea remains compliant with its current approach. It has seven partnerships already that have taken almost two years to start. Every co-enterprise is extremely time consuming since proximity is critical to the success of each enterprise. Patrice Garneau even believes that Pangea has its limitations: ''The model has limitations. I'm not sure Pangea can expand beyond 10 or 15 partnerships'' (farmer and Pangea partner, personal communication).

Another respondent, Robin Godin Gauthier, had a different perspective on Pangea's strategy and how scalable it is: ''We do believe that the model is scalable. We are committed to processing but we need good partners. We want to build a crushing plant for Patrice so he can develop the regional market'' (Pangea's Agrologist, personal communication). This statement is based on how the model can support vertical integration, something a small-scale farm is not able to do under normal circumstances. Vertical integration is something that Pangea is very interested in for its AOP's because they see it as another way of reducing the risk of AOP's not be able to meet rents (Charlebois and Summan, 2014).

Agriculture is a capital-intensive industry, as capital cost affects the viability of agricultural investments. Co-enterprises created by Pangea lowers the cost of capital, and helps mitigate financial risks for the farmer operator (Deinenger, 2013).

It is also difficult to see how current partners would want more co-enterprises as part of the network. Incentives to find new farmers for current partnerships remain ambiguous. Finally, political factors were considerably influential in Pangea's case. One can also venture to state that Pangea underestimated political forces. Segregation or even marginalisation became evident while assessing the point of view of a farmer. The UPA distanced itself from farmers opting for a partnership with Pangea. The farmer interviewed was surprised to realize after a while that his own union made him an outcaste: ''The UPA never approached me about Pangea, at any time. The UPA always supported us, but not since Pangea has been involved. It surprised us'' (Patrice Garneau, farmer and Pangea partner, personal communication).

In its inception, Pangea made a case to the provincial government and ask it not to intervene in any way. Pangea stated in meetings that its intent was to create wealth for regions, beyond agro tourism and natural resources. Pangea made a conscious effort to meet with officials beyond farming. Marie-Christine Éthier, Director of Communications, stated that, ''Being accepted by communities was a priority from the start. With what happened between the region of Lac St-Jean and the National Bank'' (personal communication).

Transparency also became key for Pangea as it battled disapproval. They met different key political and economic figures and posted key information on their website on a regular basis. Robin Godin Gauthier, Pangea's Agrologist, explained that, ''Pangea is very transparent. As soon as we bought land and created a partnership, we posted everything on our website, so a registry won't make much of a difference to us'' (personal communication).

Attributes of communities mirror the political and economic reality of the system. These are elements that are not easy to change. These elements can be socio-economic, technological or even judicial. The concept of limited partnerships appeared difficult for farmers to understand. Some did not believe what Pangea was promising. Staff at Pangea have spent a great deal of time explaining the concept due to the fact that most farmers are inherently not accustomed to partnerships. Marie-Christine Éthier, Director of Communications, stated that, ''The UPA was willing to meet with us at the beginning, but afterwards, they refuse to meet with us. They felt that the model was too good to be true'' (personal communication).

Pride of land ownership also came up as an attribute. In Pangea's case, while farmers are mostly proud of their farmland as they see it as their legacy, some have made the observation that most farmers lack the skills to operate a farm on a much larger scale. Even further, Sirois suggested that farmers do not have the same level of professionalism one can find in other sectors. However, some farmers do approach Pangea with an objective that is not compatible with Pangea model. As Robin Godin Gauthier stated, ''We need partners who are entrepreneurs and are willing to learn'', and he continued, ''Many come to us with extreme financial difficulties, or they just have the wrong personality'' (Pangea's Agrologist, personal communication). Similarly, Charles Sirois stated, ''It's amazing how many farmers don't know how to farm on a larger scale. Training is key. They rarely know what their returns actually are''. He went on further to say, ''What does business mean in agriculture? It's different than in other sectors. It's a much more sensitive business than other sector I have been involved with. There is also lack of professionalism in agriculture. Most don't seem to have a preoccupation around productivity. They are protected all the time. The fact that mistakes in operational farming should be compensated by society is a strange belief'' (Co-founder of Pangea, personal communication).

Most rural communities have embedded rules that affect the discourse between agents in a political economy. Trust seems to be a very important factor which rides on the whole notion that partners in rural communities are trustworthy. Robin Godin Gauthier commented on the issue of trust: ''Pangea basically gives partners keys to the house, so trust is very, very important'' (Pangea's Agrologist, personal communication).

Trust is likely the most significant vulnerability of Pangea's model. Both Pangea and rural communities appear to be at odds when evaluating rules which influence their behaviour. Pangea had to earn its social license throughout the process as it was not seen as a member of community. Also, Pangea's core values differ from traditional, artisanal farming. It does not seem to appreciate why society should support operational mistakes made by farmers, which in turn nurtures a culture of neglect and misuse of resources. What became clear is that Pangea had to manage an environment in which most entrepreneurs felt they operated under the protection of the UPA. Pangea underestimated how difficult and unpredictable the UPA would be.

Action Arena

Looking at farmland management as a political economy, some groups appear to have fared better than others. The UPA, for example, was very vocal for a while but one respondent mentioned that the group may have neglected much larger issues in the process. Despite Pangea's good intentions in reaching out to the community, opinions and perceptions shifted. Director of Communications, Marie-Christine Éthier explained, ''We met with regional chapters and people at head office. At first, the message was well received. But later we realized that the UPA was not pleased with what Pangea was doing'' (personal communication).

Pangea was not able to explain why these shifts in perception were occurring. Pangea felt it was important to protect its partners, but were not sure why it was doing it, or if it was needed. From a communications perspective, the will is to make farmers the face of Pangea. Robin Godin Gauthier believes that, ''The UPA demonised Pangea, but they have much bigger problems to deal with in the near future. They will likely stop talking about Pangea. While they were dealing with us, they did not see other issues emerging like TPP (Transpacific Partnership) or CETA (Comprehensive European Trade Agreement)'' (Agrologist, Pangea, personal communication). Katy Dupéré also stated that, ''The UPA is not really a threat. They have a political position to defend and that's what they do. But what is clear though is that we are not land grabbers. Pangea's model is largely misunderstood'' (in-house Lawyer, Pangea, personal communication).

A great deal of time was spent addressing issues and managing political agendas within the establishment of farmland governance. According to Pangea's Co-Founder, Serge Fortin: ''Our communication strategy is based on transparency, availability, and honesty. I have spent more time explaining, even justifying the model than actually working with partners, but things have calmed down'' (personal communication).

Mr. Fortin, a farmer, became the spokesperson for Pangea, but gave other partners the opportunity to speak for themselves. At the commission, both Mr. Fortin and Mr. Garneau testified providing Pangea farmers with a voice. Even though it was clear that the UPA was purposefully attacking Pangea, the communication strategy never acknowledged the farmer's union in its communication strategy. ''We never mention the UPA in our communication strategy. We conducted many face-to-face meetings. They seem to be more productive'' (Marie-Christine Éthier, Director of Communications, personal communication). Pangea mentioned it has no regrets with its communications strategy and would adopt the same approach again. Charles Sirois stated, ''We meet every year to build a family, the Pangea family. We are creating our own UPA, really'' (Co-Founder of Pangea, personal communication).

Pangea's aspirations is to create a knowledge network to support families and farms, which is an area served mainly by the UPA in the province. Pangea is likely perceived as a threat. It seems that members have raised concerns about other issues, beyond farmland management. The UPA has been much less active after the commission. Trade agreements are a great source of concern for farmers in Quebec and have become more important issues for the UPA. Pangea is now looking at Ontario as a potent market for its model, the largest province in the country. As Robin Godin Gautheir noted, ''Ontario is a different market. They seem to not have that regional, protectionist mentality. This is why we want to expand in Ontario in the future'' (Pangea's Agrologist, personal communication).

The arrival of Pangea also jumpstarted a cognitive process which has made many young farmers realize that capacity is a challenge. In order to grow and to run a sustainable operation, it is critical to own more land. More young farmers are having that debate right now. But growth for Pangea will likely remain a challenge. It became clear during interviews that the proximity to offer support was key for co-enterprises. Jean-Paul Tardif, Director of Operations at Pangea, stated, ''We encourage farmers to call us and to seek some advice. Typically, during the first year though, they like to show they know things. But after, they get more comfortable, more vulnerable with Pangea.'' He went on to say, ''We hope to get 20 partners in Quebec, perhaps more in Ontario. The important thing is proximity. We need to provide the proper support on site for the model to work'' (personal communication).

Expectations of farmer-operators that affect Pangea's ability to manage a greater number of limited partnerships is high. The support provided is time consuming and costly. Keeping a lawyer in-house, for example, is unusual for a firm of this size. At the beginning, Pangea insisted in having a lawyer in-house to deal with farmers and partnerships when the company could have sought council externally and transacted through any well-known legal firms in Montreal. Katy Dupéré explained ''Pangea wanted me to be in-house, to be close to Serge, and farmers. At first, it would have been more difficult for him if I would have been external'' (in-house lawyer, personal communication). Dupéré has now left Pangea and has her own practice. However, she remains committed to serve Pangea in the future. Most of Pangea's limited partnerships are not profitable. However, the company expects most to be profitable by year 3. Pangea is confident that this objective will be met.

9. Discussion

Evaluation criteria that impacts interactions and outcomes for Pangea's model in the context of a political economy are difficult to define and assess (see Figure 1). Pangea's approach is certainly in sharp contrast with other existing farmland investment schemes. Irrespective of whether a rural region in Quebec or elsewhere aims to attract investors, increased land values necessitate institutional innovation to improve land governance. Pangea's arrival in the political economy of farmland management allowed most to recognize that some gaps are perceived to exist in the legal framework, whether gaps do exist or not. We could also argue that western societies may need to reflect more on what is and what is not acceptable in terms of farmland ownership and governance for their country.

Looking at Pangea and agriculture, it is relatively easy to conceive of the relationships between financiers and agriculture as an unnatural coupling. This reflects two key assumptions that underlie much of the research on the ''financialization'' of food. The first is that finance and agriculture represent two distinct sectors that have been brought together and thus linked as a result of the business enhanced hype in agriculture-based investments. While this opposition is based on the fact that agriculture is meant to create wealth by way of physical effort, the finance sector is, in some ways, often credited for generating wealth in a virtual fashion. Pangea makes this fundamental dissimilarity more obvious between the two worlds. The financial sector represents an unnatural or artificial influence on agriculture, undermining the normal course of ''price taking''. Finance is about control, hedging and most importantly, it is about distorting the ordinary functions of agrifood markets. Pangea's opponents have galvanized the distrust expressed towards the ''financialization'' of food (McMichael, 2012). What is often missing from these exchanges within a political economy is an understanding of what ''financialization'' looks like in practice. These misunderstandings could lead to confusion, fear and prejudgement, as it did with Pangea. No mediation mechanism to accommodate discrepancies is in place, which only can make the situation worse.

Beyond the model, the most interesting aspect of Pangea is how dissimilar both Mr. Fortin and Mr. Sirois are. The common denominator is that both are highly successful business people in telecommunications. It is difficult to believe the two would create Pangea on the basis of greed as both are arguably financially independent. While Mr. Fortin is a multi-generation farmer in Quebec, Mr. Sirois is a mathematician and banker and has never worked on a farm. But Mr. Sirois is arguably one of the most well-known business persons in the province and in the country. This may have contributed to the negative perception of Pangea by the UPA, seeing the company as a speculator and a land grabber. Mr. Sorois' influence is well recognized but the association between himself and Mr. Fortin seems complimentary. One comment was made which captures how Pangea dealt with Mr. Sirois notoriety: ''Charles Sirois may not be a farmer, but he knows how to start businesses. That is what he does well. We weren't trying to either hide or to promote Charles just because it was not really relevant for our strategy'' (Marie-Christine Éthier, Director of Communications, personal communication).

Farmland values are certainly a bellwether of the financial health of agriculture in Canada. As a result, producers, lenders, policymakers, and media are searching for signals and methods to provide sound stewardship in the future. The importance of public education on matters related to farmland management, economic development and resource utilization cannot be over emphasized. Local communities could embrace new models to support small-scale farms as long as they are aware and well informed of implications and of the need of their responsibility in nurturing wealth creation and ensuring sustainable resource utilization.

What may have added to the anxiety was the fact that local communities in many areas in the province of Quebec may lack the ability to assess the technical and economic viability of investments, to identify key challenges associated with them, to effectively negotiate intricate contracts, or to enforce compliance with such agreements even if judicial infrastructure were available. This, of course, was fuelled by the highly organized and well-resourced UPA which capitalized on specific attributes of rural communities to generate more conflict. Pangea's Co-Founder Mr. Sirois stated, ''I never expected so much opposition by the union. They state they don't want speculators, but I don't either. They just don't believe us'' (personal communication).

The Pangea model revealed an underlying fundamental problem of lack of faithfulness and/or trustworthiness on the part of some of the parties involved in the conflict. The UPA and the Parti Québécois strongly opposed the model, even two years after the first limited partnership was established. For instance, the projected gains in the community, direct and indirect were found to be grossly unbelievable during visitations in different regions. In addition, Pangea was perceived as an urban agent, attempting to control agriculture in regions. Interactions led to disbelief. Many misunderstood or did not understand the model and assumed farmers became Pangea employees. Patrice Garneau spoke against this misunderstanding, saying, ''Most people misunderstand the Pangea model. Most thought we became employees of the firm and worked for Pangea, which obviously is not the case'' (farmer and Pangea partner, personal communication).

Strong political will and commitment to a healthy environment on the part of Pangea, and truthfulness and fairness on the part of investors was, and continues to be, essential in the implementation of the plan as fears of Pangea have dissipated over the last year.

This case study underscores the importance of public awareness on matters related to sustainable financial models in farming, and on matters of development and resource utilization which are vital, if local communities are to participate effectively in maintaining a vibrant agrifood economy. Protecting the interest of local entrepreneurs is also critical. The persistent opposition from the communities and other more well-organized parties opposed to Pangea increased attention on this new model and the issue of farmland ownership and eventually resulted in a parliamentary commission. Pangea demonstrated resolve throughout the process and opposition against the model has almost disappeared. Pangea's initial intent was based on geo-economics, but the company was committed early on to addressing the political aspects of farmland ownership. It broadened its action arena as it went along. Such a strong political will and commitment to a healthy environment on the part of Pangea only discloses that truthfulness and fairness on the part of external investors in agriculture are essential.

Some limitations ought to be considered when reading the case. Firstly, this case study relies only on the co-authors' specific knowledge in the sector to accurately depict the agents involved in the sector. It also relies on the types of relationships and how they interact since an in-depth analysis was only achieved by involving the targeted unit involved in the case. Since this is a singular case, findings in this case may not be necessarily applicable for other cases. Nevertheless, it does provide a sense of how one model may be considered for future endeavours. Furthermore, the chosen methodology only provides the scientific community with a ground for an effective consolidation on farmland management concepts, as it offers practical knowledge and contributes to the scientific development of farmland governance.

10. Conclusion

The latest increases in farmland prices, and returns driven by rising commodity prices have led to significant increases in both the value of and rental rates associated with farmland exploitation (Paulson and Schnitkey, 2013). At the same time, ongoing research is needed to examine changes to agriculture policies to protect farmland in urbanizing counties over time. Investing and farming are increasingly becoming interchangeable. The Pangea case speaks to how both worlds are colliding and how conflicts could emerge in political economies. Financial markets are increasingly virtual and abstract, separated from the physical form of agricultural commodities. The Pangea approach may be the most effective and it certainly offers one avenue of attracting major capital to farming and of allowing farming families to access this capital (or its usefulness) to grow and sustain family farming enterprises.

Certainly, over the last few years it has been noticed that economic cycles have an impact on urban development and pressures from both the residential and business sectors. This factor should be considered in future research. Furthermore, studies that examine locations over time will help understand farmers' methods of coping with different economic circumstances.

Future research should look at how scalable the Pangea model is and how it can be adapted for regions where food insecurity is very real. Properly assessing how transferable the model is remains to be seen. Many industrialized countries with large amounts of arable land that investors might want to bring under usage have a limited appreciation of the resources at their disposal. The most appropriate ways to add value to these, while using human capital already available, should be further developed. Pangea's model represents one method to contribute to growth and equity on a broader scale for farming and agriculture. Mr. Sirois has expressed that Pangea has ambitions beyond Canada, ''My goal is to convince the World Bank to invest in Farmland, but they ask me to prove it, so we did'' (Co-Founder of Pangea, personal communication).

It is the complexity and messiness of the financial sector's involvement in agriculture that stands as a key lesson of the Pangea case and that offers the most fertile ground for future research. After almost two years the model appears to be delivering, but a more longitudinal evaluation is warranted. It should expand on a much larger scale to see how Pangea's approach can support developing countries. From this case study, it would appear that Canada is a test for other projects which would likely be more influential in addressing the issue of the lack of access to capital by farmers and its relation to global food insecurity. But this case suggests that the support system for co-enterprises needs to be refined in order to support growth of the model.

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Acknowledgement

The authors would like to thank Pangea for being so open to our queries. We also woulod like to thank the Editor and the anonymous reviewers for their insightful and constructive comments from which the present paper greatly improved.

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DOI: 10.5836/ijam/2017-06-123

Potash fertilizer to agricultural based economies

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ABSTRACT

Potash is an indispensable element in agricultural development and innovation. It is relatively cheaper to mine, produce and be imported compared to other fertilizing materials such as nitrogen. This makes potash a viable material for agricultural based economies such as New Zealand. Despite the well documented benefits of potash, there is limited scholarly interest in the potash global market, its potential and economic advantages. This paper fills this gap by providing an overview of the potash market using secondary data provided by the Food and Agricultural Organization of the United Nations. Further, this research presents a market analysis of the potash industry worldwide. Most importantly, the study argues that the prospects of potash production can be realized by countries such as New Zealand without significant changes or investments in the existing agro-economic infrastructure. We will also consider the size of the market and future perspectives for potash demand in New Zealand. Furthermore, a critical analysis of potash consumption and production by the country will be done. The influence of the demand on the price and interrelation with the global volume of production will be considered. This research uncovers the negative impact of oligarchies on the mining, production and importation of potash. It also highlights the significance of diversification in New Zealand's future agricultural development strategies. The burgeoning of Eastern European Potash markets offer New Zealand's farmers the opportunity to access cheaper, better and diversified products greatly improving their local and to be exported crops.

KEYWORDS: agriculture economy; belaruskali; canpotext; fertilizer; potash, potash market, uralkali

1. Introduction

Agriculture in New Zealand occupies the largest share of the country's economy. While this sector is composed of several smaller markets, the fertilizers market is one of the most important parts of New Zealand's agricultural industry. Potash is one of three main types of fertilizers that are used worldwide and is currently under-utilized in New Zealand's agricultural life despite its well-documented benefits, prospects and ease of access and importation. (Jiang, 2003).

Human population growth has increased the mining, production and use of Potash significantly enlarging its market by 3% worldwide in 2016. People require more food and use more fields for agricultural development, therefore they necessarily consume more fertilizers such as potash increasing crops' yields. there are few places in the world where mining potash is economically reasonable. Almost 90% of all known reserves are situated in three countries: Canada, Russia and Belarus (Jasinski, 2012).

During the past few decades, the price for potassium nutrients was extremely unstable. The potash market is very narrow and is not traded on stock exchanges. Many analysts have argued that oligopoly is a major problem in the Potash market. Few large companies have consented to keep prices high. Up to the end of 2006, the price of a ton of potash was less than $200. Then it drastically increased reaching a $1000 US in 2008 until the global financial crisis reduced the price. In 2013 the agreement between the two largest companies Uralkali and Belaruskali was cancelled. These two companies shared more than 35% of world market and due to their business conflicts, price of potash decreased dramatically. In 2015 Belaruskali signed a contract with the largest customer, China, selling Potash at $315 per ton.

New Zealand companies only import potash from Germany and Canada at higher prices. This prompts policy makers to reconsider the current New Zealand's strategies concerning potash importation. It is more reasonable to start looking for other suppliers in different parts of the world (Roberts, 2014). Another possible reason to start

Original submitted March 06 2017; revision received October 07 2017; accepted October 26 2017.

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buying from different places is the lack of production in Germany, since reserves of potash in this European country are almost exhausted.

The main aim of this article is to assess the potash market worldwide and then assess the demands on this fertilizer in New Zealand. Potassium does not need a complex processing to become ready, unlike other fertilizers such as nitrogen and phosphate. This made potash producers almost 100% importers, and Uralkali and Belaruskali from former USSR republics Belarus and Russia are not an exception from the rule (Volkova, 2015). Not many firms are operating on the potash market. However, a huge amount of commodities must be delivered from the opposite side of the planet when it comes to potassium for customers in New Zealand, which also makes influence on the final price. Suppliers must be reliable, experienced and at the same time able to react quickly if the situation on the market alters.

To achieve the aim of this research, potash markets from different countries must be compared. It is extremely important to clarify the ability of companies to follow the contract and deliver the exact amount of goods on time, as agriculture is a seasonal industry. Hence delays may have a negative influence. For that reason, production volumes and stability must be checked and be compared to other market players. Price is another important factor to take into consideration.

This research has several objectives. Firstly, we analyze the amount of annual potassium production between current suppliers to the New Zealand market and Uralkali with Belaruskali. Then, we compare reserves of fertilizer that both companies own. Beside potash price fluctuation, as potash is not trading on stock exchanges, it is possible to analyze its price by comparing contracts of primary consumers, such as China, India and Brazil. By combining all these objectives, it is possible to forecast future perspectives of the global potassium market. The following questions are clarified in this report: how reliable are importers from Belarus and Russia; and what benefits can New Zealand farmers expect when getting potash deliveries from that regions.

Scholarly research on potash mining, production and importation by industrialized countries such as New Zealand is limited. Most analysts discuss potash within the general fertalizers' framework and ignores the several benefits of considering it on its own. This has led to the underestimation of the mineral' potential in agricultural use and cost-effectiveness for agricultural development. New Zealand's agricultural sector can improve significantly if potash is optimally purchased from new markets and utilized efficiently.

2. Literature review

2.1. Potash

When it comes to the agriculture industry, potash is a solid single nutrient or straight fertilizer. It has been used from ancient times, however the industrial mining of it started in the middle of 19th century in Germany (Figure 1. The author of this research in a potash mine near Kassel in central Germany, 800m below the surface). Extraction of the potassium is a complicated process. Deposits of this salt are lying under the earth surface at depths between 350-1000 meters (International Plant Nutrition Institute, 2010).

The plant's growth requires sunlight, water and nutrients, and the three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). An insufficient amount of any of these elements in the soil leads to the limitation of the plant growth and to the yield reduction. Fertilizers provide plants with the necessary amount of nutrients at the appropriate stage of the growth. The proper use of fertilizers can increase the yield in two, and sometimes even three times. Potassium activates more than 60 enzymes and ferments which are necessary for the synthesis of proteins and carbohydrates. Among the ingredients of the potassium-based fertilizers are substances that are perfectly soluble in water. When the soil is fertilized by such substances, the chemical reaction with the existing components starts immediately (Jin, *et al.*, 2012).

There are several main periods during the crop growth for the potash fertilizers:

- The pre-sowing or basic fertilizer is applied in autumn or spring, based on the temperature conditions of a particular climate zone. Fertilizer before sowing provides green culture with nutrients for the whole season.

Figure 1: Author of the report in the salt mine 800m below the Earth surface near Kassel, central Germany, 2013

- The sowing or starting fertilizer is applied during the planting. It helps the root of the young plants and ensures the stable growth on the early stages.
- The post-sowing fertilizer is an additional step to the above methods. The main objective of it is auxiliary nutrition at the peak of the crop growth and replenishment of the missing elements.

Different types of plants require different amount of potash. It depends on weather conditions, season, type of soil, crop yield and other factors. Potassium helps plants to keep the humidity of the soil, increases the nutritional value, and improves the test and color of the product. When a plant receives enough potash there are following benefits:

- oxidation process in cells is more intense
- cellular metabolism enhanced
- increased resistance to the lack of humidity
- photosynthesis accelerates
- plant quickly adapts to temperature changes
- increased resistance to disease

The main aim of using potash is to compensate for the lack of nutrients caused by human or by nature and to get higher yields. It is the same in both tropical and temperate climates. As the area of pastoral fields in the world is limited and the population of humanity is increasing, there is no other way to get more food than to use more fertilizers. An example of this is in developed countries, where potash used by the hectare is almost four times higher than in developing countries. In Russia potash use is 40 kg per hectare and in the USA it is 140 kg per hectare (Volkova, 2015).

The Food and Agriculture Organization of the United Nation (FAO) has predicted that the world potash market will be increasing 2.8–3.3% per year. Latin America and Asia are making the biggest impact on it, as shown in Figure 2.

The main factors, which influence the global fertilizer market is the growing of Indian and recovery of Brazilian economies, although at the same time the unstable and unpredictable situation in China makes this forecast less reliable. New Zealand does not play an important role in the global potash market, despite the main role of agriculture in their economy.

According to the industry experts, the global consumption of potash in 2014 was 62 million tons. In monetary terms the annual turnover was approximately 20 billion USD (Petrov, 2015). Figure 3 shows the production of potash in 2014 by countries. According to the market specifics it is common to consider the whole country as a single customer or a producer. There are three large producers of potash worldwide: Canpotex Ltd. (Canada), Belaruskali (Belarus) and Uralkali (Russia).

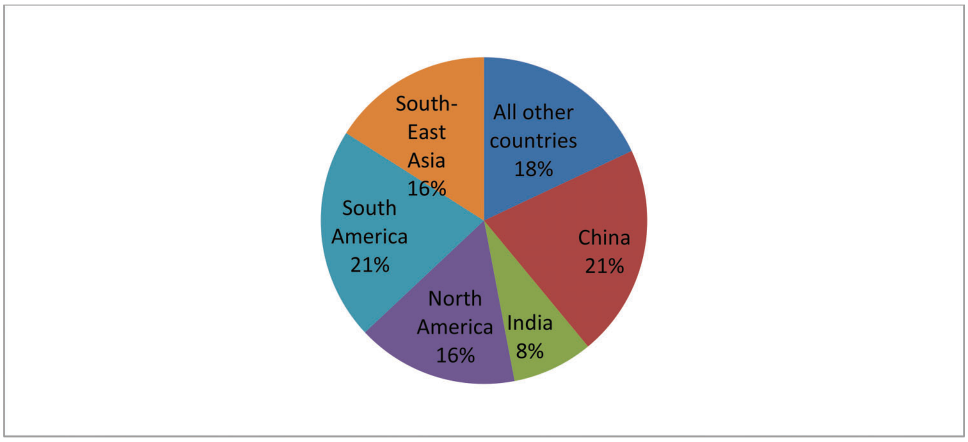

Figure 2: Potash use by region. Source: FAO

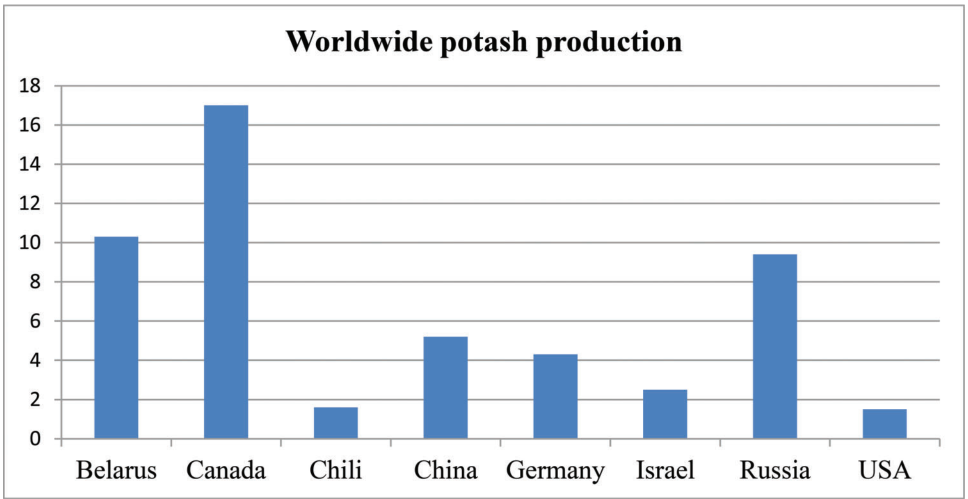

Figure 3: Worldwide potash production by country, 2014. Millions of tons

2.2. Potash Primary Producers

2.2.1. Canpotex

Canpotex was founded in Canada with the purpose of exporting fertilizers all over the world. Shareholders of this company are Mosaic Canada, Potash Corp. of Saskatchewan and Agrium Inc. Canpotex is the only firm from the top three producers that operates not only on the potash market, but also in sales of superphosphates and nitrogen fertilizers.

The Canadian potash producer has a close cooperation with the government. For example, in April 2005, it received a 10-year tax relief from the Provincial Government of Saskatchewan. In response to this positive move, Canpotex invested in increasing the capacity of potash mines in Saskatchewan. The Canadian potash importer is constantly developing and has numerous projects. Logistics is an important part of the industry as commodities count by tons and even small contracts include supplying thousands of tons. Recently, Canpotex has invested more than 140 million Canadian dollars in Portland Bulk Terminals. They also agreed with National Steel Car of Hamilton (Ontario, Canada) to manufacture 700 railcars for transportation of potash from Saskatchewan mines to coastal ports. These facts show that Canpotex is an important Canadian firm.

2.2.2. Uralkali

Uralkali has its main office in a mining potash area called Berezniki in the Perm region, Russian Federation. The company was founded in 1926, after potash was recognized in Solikamsk by Professor Preobrazhensky, from that time Uralkali is constantly developing and modernizing their production according to industry standards. The first huge modernization was in 1950s-1960s, when machines changed human work. From that time Uralkali increased their production capacity step by step. Nowadays Uralkali has a share of 20% of the global potash market and sells their product to more than 60 countries all over the world. Main markets are China, India, Brazil, South-Eastern Asia, the USA, and European countries. A further 16% of all mined potash goes to the internal Russian market. As the logistic component is significant, the company has storage for 640,000 tons of the product and 8,000 railcars for delivering potash to customers and to coastal ports. Even this is not enough during the peak season, so Uralkali hires railway transport from logistic companies and additional storage in Ventspils sea port.

The Russian potash producer is investing a lot into a scientific activity and R&D. With their support in 2009 the Kali Institute was founded in Perm Region. Since 2012, Uralkali is developing a project of increasing crop yield in agriculture. Such scientific programs give benefits to both, farmers and the company. Farmers get a higher crop yield, Uralkali sells more potash. The company has several projects for increasing the capacity which have already been launched. New mines Solikamsk-2, Solikamsk-3, Ust-Yayva and Polovodovo will start to work in the near future. According to the plan, Solikamsk-2 is able to increase capacity by 2.3 million tons and requires the total investment of 723 million USD. Solikamsk-3 is able to provide additional 0.6 million capacities and requires 135 million USD of investment. Ust-Yayva estimated capacity will be 2.5 million tons, and its total investment will be 1.12 billion USD. The biggest project is Polovodovo with a future capacity of 2.8 million tons and 1.9 billion USD investments. With all these projects, Uralkali can almost double its current capacity. Figure 4 shows estimated growth of Uralkali potash mining according to the company's future business plan.

2.2.3. Belaruskali

Another important player on the global potash market is Belaruskali from Saligorsk, Belarus. According to IFA Belaruskali produced 1/7th of all potash in the world in the year 2015. Almost all the mined product was imported, as the Belarusian market is quite small. As it is possible to recognize from the company web site, Belaruskali exported potash to more than 70 countries. The first potash mine was built in 1949 in Starobin. The mine gives a start to the city Saligorsk, which was built to supply Belaruskali worker's needs. In 1981 Belaruskali reached the point of 100 million ton of mined potash.

The Belarusian potash producer is constantly increasing its capacity. In 2014, the company started the Petrykau project. According to the plan, the mine in Petrykau will reach full capacity by the year 2020. For the aim of potash exporting, in September 2013, Belaruskali established the Belarusian Potash Company. A company with the same name operated in the market previously and was selling commodities from two large potash suppliers in the region, Belaruskali and Uralkali. However, the

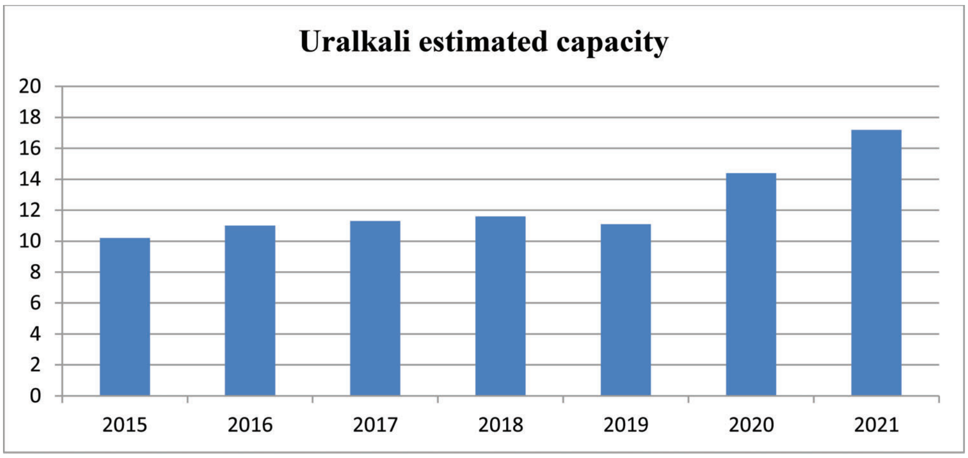

Figure 4: Current and estimated capacity of Uralkali, million ton

business relationship with Uralkali was broken in 2013 and after a few months a company based in Saligorsk started to sell potash separately. Now the Belarusian Potash Company has several offices worldwide including Delhi, Beijing, Singapore and Sao-Paolo.

Belaruskali is 100% owned by the government. Since Belarus is not a member of WTO and other financial and economic organizations, the information from the company does not follow international standards. At the same time, Belaruskali and Belarusian Potash are members of IFA and send reports to this organization. Moreover, FAO collects statistical information from governments, including data connected to the fertilizer industry, which is used in this current paper.

2.3. Potash in New Zealand

New Zealand is totally dependent on imported potash as there is no source of it inside the country. According to statistics from FAO, New Zealand imports around 100,000 tons of potash per year. Unlike the rest of the world, consumption of this fertilizer in New Zealand decreased during the last decade. However, since 2010, quantities imported potash stabilized to 100,000 tons per year, as shown in Figure 5.

Agriculture in New Zealand is the largest sector of the tradable economy, contributing about two-thirds of exported goods (Brazil, 2008). The land area, devoted to horticulture, has increased during recent years. Total horticulture exports reached 2.45 billion of dollars in 2012. Average production of grapes is more than 200,000 tons per year. Also important products of the horticulture industry are peaches, nectarines, plums, apples, kiwifruits, avocados, onions and squash. All these, and many others, require fertilizers for high crop yield and for the good taste and quality. As the horticulture is a growing industry in New Zealand, the likelihood that the quantity of potash used will decrease is negligible.

3. Critical analysis

The years 2014 and 2015 can be considered successful for the global potash market. Consumption of potash was increasing by almost 4%. Key markets were recovering faster than had been predicted and there were increasing demands, primarily from China, India, Malaysia and Indonesia. However, prices have fallen down. Because of the business conflict between Uralkali and Belaruskali in 2013 Belarusian Potash has suspended its operation. Customers were unable to purchase potash in the East-European market. In 2014 customers refilled their empty storages. Demand in China grew up to 24% and markets in South-Eastern Asia demanded over 10 million tons in 2014 compared to 8.1 million tons in 2013. Significant increases in demand were observed in Brazil, about 20%, and India signed contracts for 4.3 million tons in 2014 and 4.6 million tons in 2015.

The North American market had a stable high demand. It could slightly decrease in the near feature since less corn are planned to be produced. European, Middle-East and African markets showed the same level of consumption. The average load of production in the industry was 83-85%. Russian and Belarusian producers showed record levels of production. Figure 8 represents potash production by country from 2001 up to now. Data from 2001-2011 was taken from U.S. Geological Survey (Jasinski, 2012) and IFA, later data – from companies.

Figure 6 depicts that potash production in the world grew up from 2001 to 2014. However, the growth cannot be considered as stable. In the years 2006, 2008, 2009, 2012 the number of mined potash decreased due to different reasons. In 2006 and 2012, main potash customers had a lot of potash in storage and refused to buy more due to world instability. Most potash suppliers were simultaneously reacting to demand except Belaruskali. In 2013 the Belarusian company mined a smaller amount than expected. The problem was due to breaking relationship with Uralkali, after which Belaruskali almost stopped production for a few months as it lost sales markets.

New Zealand potash consumption has been stable for the last five years. The current global situation, when the production is increasing as a result of competition for market share between leaders, is positive for New Zealand importers as it gives hope for a stable low price. Production in different world regions has been changing in the same way for the last decade. It gives a confidence that all suppliers considered in this paper, Canadian and East-European, are equally reliable.

The price for potash has been stable for decades. However, in the last 10 years there was significant price fluctuation. There was a jump from 120 dollars per ton in early 2000 to almost 900 in 2008. Then, under the influence of the global financial crisis in 2008, it decreased to 300 USD in 2010. For the last two years the price for potash has fluctuated near 300 USD per ton. The most

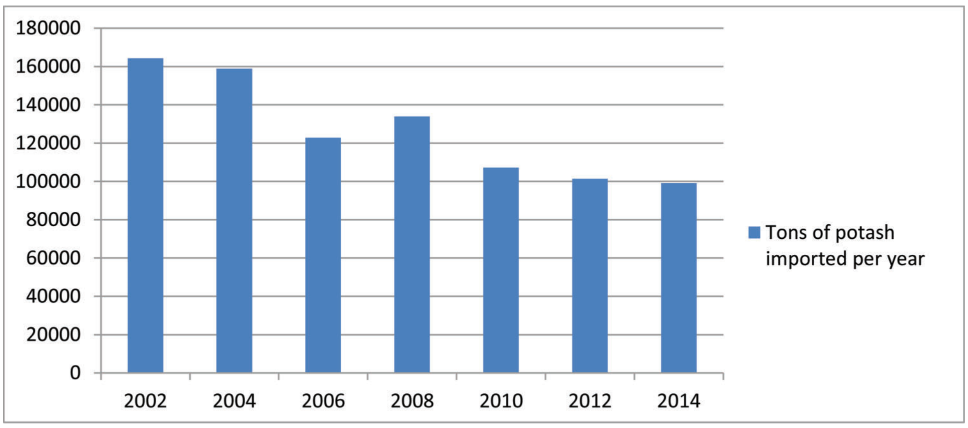

Figure 5: New Zealand potash import

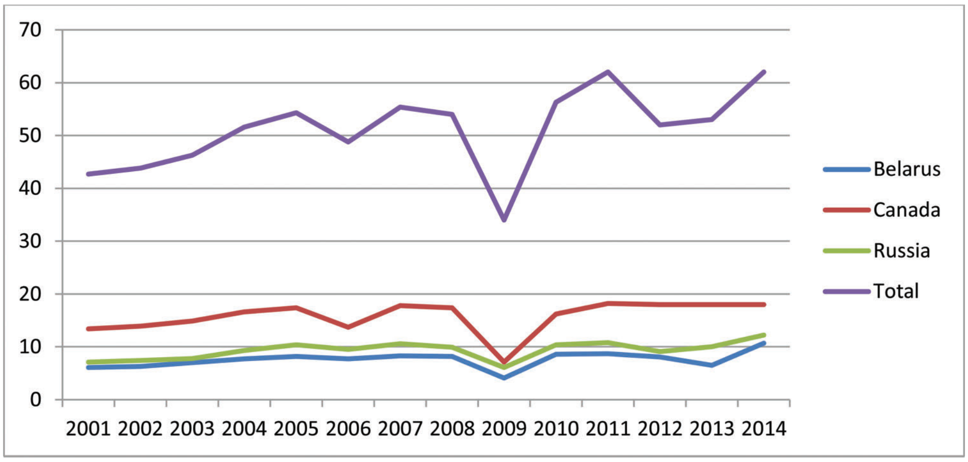

Figure 6: Potash production by country, millions of tons

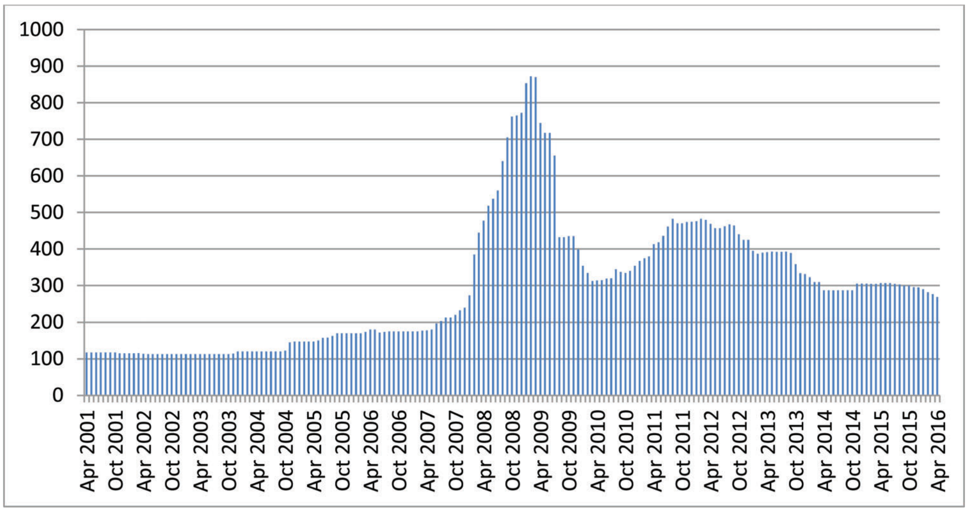

Figure 7: Price for potash, USD per ton. Source: World Bank

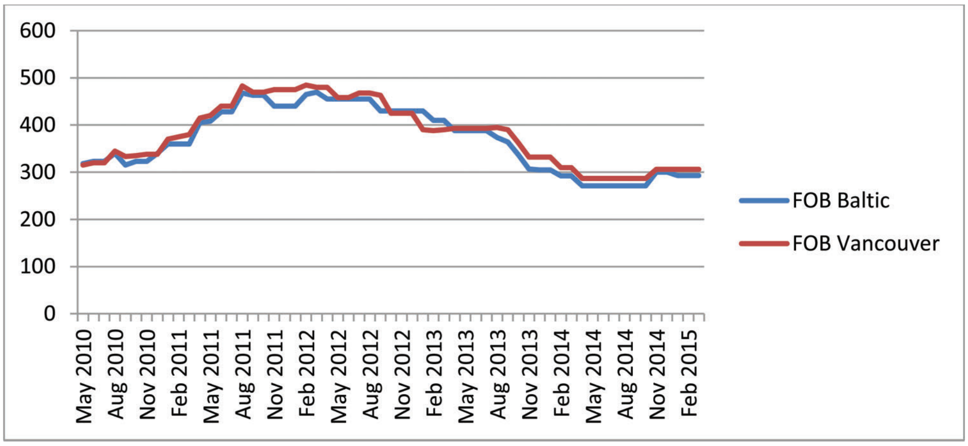

Figure 8: FOB Baltic and FOB Vancouver contracts prices for potash, USD per ton

important event for this year is that India halted potash imports because droughts hit the crop fields in the country. As a result, price is going down again.

As the most significant potash producers are situated in Canada and Eastern Europe, to compare their prices we can observe contracts on FOB Baltic and FOB Vancouver basis (Incoterms 2000). The data has been collected from IFA and company web sites. Canadian potash was more expensive during the last five years. However, there was a period of time in the end of 2012–beginning of 2013 when potash in the Baltic port cost more than in Vancouver.

For New Zealand importers, such as Balance Agri-Nutrients, Ravensdown Fertiliser and Summit Quinphos, the average difference in 10 USD per ton can save 1 million USD per year, as their need is 100,000 tons. The total price for any kind of goods for New Zealand customers is definitely depends on logistic costs. However, as potash normally delivered by ships, which are the cheapest possible transport, the difference in transportation price cannot be high. It means that price based on FOB Baltic could be considered as permanently lower for New Zealand companies.

4. Conclusions

The potash market is specific as the main resource deposits are concentrated in a few places in the world. There are limited numbers of players on the potash market worldwide including Canpotex (Potash Corporation, Mosaic and Agrium) in Canada, and the Belarusian Potash Company (Belaruskali and Uralkali) in Belarus. European commission classified the market as an oligopoly in 2010. According to the antimonopoly investigation in the USA in 2008-2012, these two associations coordinated prices with each other. That was the main reason of unexpected growth of the potash price in 2008.

In 2013 Belaruskali and Uralkali broke business relations and started to divide markets. This changed the situation dramatically. The consequence of this act is that world suppliers of potash began to increase their production capacities and the price decreased. New Zealand fertilizer importers can choose where to buy potash. Currently, all potash entering the country is only from Germany and Canada, so we believe, it is the right time to start to diversify suppliers. This is since the commodity is cheaper in Eastern Europe, however the price difference is not significant. It is surprising as costs of mining in Belarus and Russia is significantly less than in Canada. According to statistical data provided by Uralkali, the cost of one ton of product for Uralkali is 58 USD, for Belaruskali is 86 USD and for Canpotex is 135 USD. At the same time the price for a ton of potash is almost the same and customers can choose where to buy. The profit of Belarusian and Russian companies must be reasonably higher and allow them to invest more in their growth. However, it is definitely not so for Belaruskali, as company is owned by the government and the revenue is tumbling.

Comparing two potash producers from the former Soviet Union, Uralkali looks more preferable. The Russian company owns the biggest potash deposits in the world. Also it is very important that this company follows international standards as it has foreign investors. Even though by all parameters Belaruskali is not losing to its competitors, it is still a closed government-owned firm and not all information about it is reliable.

For the New Zealand market both potash producers can be considered as potential suppliers. Their productivity is stable and even if it changes, it is only a response to the global market situation. It means that they are reliable partners and can deliver the amount of goods required. The price in Eastern Europe is lower, even though logistic costs can influence it and minimize the difference with the price in Canada. One of the findings of this business case is that oligopoly exists not only among potash producers, but also inside the New Zealand fertilizer market and there are only three importers in the country. It has been empirically proved, that absence of competition has a negative impact the potash market. Hence, a few more fertilizer suppliers will be definitely beneficial for New Zealand farmers and in being competitive with already existing firms, new importers can deliver potash from Eastern Europe.

5. Limitations

This case study has some limitations. Firstly, potash is not a commodity that is normally traded on any stock exchange. This makes it difficult to find prices for it, as we must rely on information from limited companies market. The number of producers is also limited and does not allow for including a lot of them in the research. Only a few companies play a significant role in the market and must be considered. Another important limitation is that one of the biggest players on the market is government-owned. Information about Belaruskali can be accessed only from international sources. The New Zealand market is not big enough to play an important role in global potash consumptions and only three companies are operating. The situation in the New Zealand fertilizer market looks similar to the global potash market in 2008, when two associations divided it among themselves.

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PROFESSIONAL UPDATE

DOI: 10.5836/ijam/2017-06-131

Agricultural training and the labour productivity challenge

KAY I. CARSON[1]

ABSTRACT

Brexit, if or when it happens, will be a structural break to the political economy of UK agriculture. Farm businesses that will survive the shock will be those able to offer competitively priced products at home and abroad under a new, currently unknown, environmental, food and trade policy environment. Competitiveness is driven by low unit costs of agricultural production, efficient supply chains and low transport and transaction costs. The cost of labour is a very significant part of unit costs of agricultural production, but it is labour productivity that provides the key to competitiveness and not necessarily low units costs of labour. As in other industries, capital investment in intelligent technologies, which supports decision making that optimises the use agricultural inputs within a sustainable framework and reduce output waste, are the key to high labour productivity. Agricultural training needs to provide new entrants to the industry, whatever their age, with the skills to use performance data for operations and performance management as well as to deliver technical excellence. The LEAN project at Reaseheath College, funded by the Education and Training Foundation, is giving the 2017/18 cohort of Agriculture students a head-start in lean management techniques for agriculture. Reaseheath College will be publicising early results of this project at the end of the 2017/18 academic year and would welcome offers from educators working in this sector to peer review their work. Although the funded project ends this November, the LEAN project itself will run for three years so that its impact on students and employers can be properly assessed.

KEYWORDS: labour productivity; competitiveness; lean management; agricultural training; vocational training; standard work

1. Background

In the political and economic uncertainty surrounding the British government's decision to leave the European Union (EU) in March 2017, those leading and managing farm businesses are assessing the ability of their businesses to survive under the different post-Brexit scenarios. The first negative impact from the decision has been the threat to the supply of imported agricultural labour. This has been driven in part by the depreciation of sterling that followed the June 2016 referendum on exiting the EU, but more importantly in the longer term, by the uncertainty over EU citizens' rights in the UK after it leaves the union. (House of Lords, May 2017)

This crisis provides an opportunity to address two questions:

- what type of labour do British farms need to survive commercially in the next decade;
- how can agricultural vocational training be improved to meet that demand for labour, whether the UK leaves the EU or not?

2. The long-term drivers of labour productivity in agriculture

A recent Food Research Collaboration Policy Brief (Devlin, 2016) provides a very good and comprehensive review of agricultural labour use in the UK. It looks at the long-term trends that have driven labour use patterns in the past and the challenges for the coming years. Three forces driving agricultural productivity and labour use stand out:

- the long-term substitution of capital for labour;
- the continually declining market power of primary producers in food supply chains;
- the ability of agricultural employers to repress wage rates relative to other economic sectors (although the introduction of a national minimum wage rate provides a floor when enforced).

These drivers are very unlikely to be reversed in or out of the EU. Under a liberalised trade policy, they would intensify. In the medium and longer term, therefore, all agricultural production systems can be expected to continue to

Original submitted October 2017; accepted October 2017.

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see increased substitution of capital for labour, including increased use of intelligent technologies. The higher agricultural wages are relative to the value of output, the faster that substitution can be expected to be. In other words, demand for agricultural labour is likely to fall over time unless additional land is brought into agricultural production.

Production systems that currently depend on relatively low wages to be profitable, face the challenge of accessing a suitable labour pool in the short-term if migration flows are restricted in the UK after Brexit. In the medium and longer terms and to a lesser or greater degree, production will move to countries where wage rates are competitive. These sectors are the currently trade-protected, but non-subsidised sectors of horticulture, fruit, pigs and poultry production. Employed labour accounts for a higher share of total hours worked on these farms, compared to its share on other crop or livestock farms. (Total hours worked include employed labour and unpaid family labour).

Production systems that are less dependent on relatively low wages to be profitable – arable, dairy, beef and sheep production – will face a more traditional challenge to their commercial survival; this challenge is lack of competitiveness relative to imported products at home and in overseas markets. If our current trading arrangements with the EU and the rest of the world are disrupted, the costs of trading will increase – the mitigation for this threat is a reduction in unit costs of production. The good news is that these sectors have considerable efficiency gains to make through increased capital investment in intelligent technologies which support data-driven decision making and the management of those technologies. Brexit could be the wake-up call for businesses to target and achieve total factor productivity gains through capital investment and improved management. The investment will increase labour productivity by optimising the use agricultural inputs within a sustainable framework and reducing output waste, rather than just substituting capital for labour, simply mechanising routine tasks.

3. What type of labour will agriculture need in the coming decade?

If British agriculture is to succeed commercially in a policy environment which is likely to be less protective than the EU's common agricultural policy, farm businesses need to be led by managers who use capital investment and technology to improve total factor productivity and reduce unit costs of production. This is the only way in which their products will become competitive in markets open to them after Brexit, or even at home against imports. Some of these technologies will substitute for labour, but that will not necessarily reduce unit costs of production. The types of technology which will deliver total productivity gains are those that reduce output waste and support the optimal use of all inputs.

These technologies are heavy users of data and support technical decision-making, they do not substitute for it. The quality of farm management – or decision making – is the key to achieving productivity gains on farm, as it is in other production sectors. Long-term research into management practices and firms' success by the National Bureau of Economic Research in the U.S., using a panel of data covering 34 countries and 12,000 companies, found that 'better-managed firms are more profitable, grow faster, and are less likely to die' (Sadun, R; Bloom, N; Van Reenen, J, Sep-Oct 2017). 'Better-managed' in this context refers to the joint practices of operations management, performance monitoring, target setting and talent management. In summary, the three pillars most likely to support the survival of British agriculture are the appropriate use of labour-saving technology, the use of information technology to optimise technical decision-making and good labour management. There is evidence that this type of approach to farm management has delivered sustained profitability on UK dairy farms. (Carson, 2017). Labour management on these farms concentrates on training and coaching farm teams to use farm data to set targets and deliver on them through planning, daily operations management and frequent performance reviews.

4. Training the agricultural labour force for the future

Labour demand from agriculture in the coming years will therefore fall into two categories. In the short term, there will be a continuing demand for dependable workers without significant agricultural training, willing to work long hours for a relatively low wage and statutory benefits, in horticulture, fruit, pig production, poultry production, and some American-inspired intensive dairy systems. This demand, however, is likely to decrease over time as these tasks become mechanised or production moves abroad, unless wages fall significantly in the rest of the UK economy. On the other hand, there will also be an increasing requirement for a trained labour force capable of making full use of information technology for performance management and who are comfortable working under performance orientated management techniques.

Is the UK further education sector training an agricultural labour force which is not only skilled in practical tasks, but also knows to monitor and adapt its own performance to achieve operational targets? The Institute for Public Policy Research in a recent paper lists the shortcomings of the UK skill's system as follows (Dromey, J, McNeil, C, 2017):

The UK's skills system suffers from:

- low levels of demand for, investment in and utilisation of skills among employers;
- a lack of high-quality vocational training;
- a failure over decades to tackle persistent regional skills imbalances.

The first two of these shortcomings apply to agricultural training. An attempt at meeting these challenges is currently being put in place at Reaseheath College in Cheshire, through an Association of Colleges project, funded by the Education and Training Foundation. The LEAN Agriculture project aims to integrate the principles of lean management to its current curriculum offer. Working alongside local dairy farmers who have put in place formal labour management and performance management systems on their farms, the delivery of the Agriculture curriculum for the year starting in September 2017, has been revised to bridge the gap between training and high labour performance in the workplace. Every work scheme has been revised to achieve the following:

- every learning objective, whether delivered through lectures or practical sessions, is explicitly placed in the

context of the production process or system to which it belongs, whether within crop or livestock production;
- identifying the contribution of that day's teaching to value creation in the farm business;
- identifying the potential for waste creation in the process or system of production being taught;
- identifying the environmental impacts of the process or system of production being taught and the standard procedures needed to mitigate them;
- identifying the contribution of standard procedures to achieving high technical performance in the process or system of production being taught;
- identifying relevant quantitative measures and the use of electronic data management to manage technical performance daily.

Because the College delivers courses at several levels, the changes to the curriculum are appropriate to each level. The objective of these changes is to teach the learner the habits of standardised work, the importance of every task in adding value to the farm business, the importance of identifying opportunities to do things better, i.e. how to increase production, improve quality or reduce input use, alongside the technical knowledge which the College currently delivers.

However, just improving the delivery of vocational curricula will not create a productive workforce if employers do not utilise the employee's skills. To address that, Reaseheath College is working with the network of farmers who take students on their placement year, to offer students the opportunity to engage in a meaningful improvement activity on the host farm from September 2018. Improvements in this context are any changes to production processes that will result in increased output, improved output quality or reductions in unit costs without loss of product value. The student will be allocated time to identify and implement an improvement to the farm's operations, working alongside the farm team, and using lean management tools and techniques. This initiative is meant to challenge the farm teams as well as the students.

The College will be collecting data on students' performance and satisfaction throughout their courses and will disseminate its results starting at the end of the 2017/18 academic year.

5. Conclusion

The long-term drivers of labour use in UK agriculture are unlikely to change under any reasonable policy scenario post-Brexit. These drivers are the long-term substitution of capital for labour, the weak bargaining power of agricultural producers relative to that of its buyers and the ability of agricultural producers to contain agricultural wages. If British agriculture is going to succeed commercially in the coming decade, it will need to invest in intelligent technologies which have the capacity to increase total factor productivity and reduce unit costs of production. These technologies are heavy users of data for decision making and will demand a labour force trained in the disciplines of performance management. Empirical evidence shows that it is the ability of managers to train and coach work teams in the use of operational and business data for target setting, operations management and performance management which results in sustained firm profitability. Agricultural training, therefore, should be preparing learners to work in such a work environment. The LEAN project at Reaseheath College, funded by the Education and Training Foundation, is giving the 2017/18 cohort of Agriculture students a head-start in lean management techniques for agriculture. The introduction of lean techniques is not taught as an independent unit, but instead it has been integrated in the delivery of the current Agriculture curriculum offer. Reaseheath College will be publicising early results of this project at the end of the 2017/18 academic year and would welcome offers from educators working in this sector to peer review their work. Although the funded project ends this November, the LEAN project itself will run for three years so that its impact on students can be properly assessed.

About the author

Dr Carson is a farm management consultant. She has developed a management system for dairy farms using lean management principles to achieve high levels of operational efficiency. She works with farmers, growers and land colleges, training and coaching staff teams to improve operational performance by reducing waste and increasing value added. Dr Carson is the specialist consultant for the LEAN Agriculture project at Reaseheath College.

Acknowledgments

The LEAN Agriculture project at Reaseheath College is funded by the Education and Training Foundation through the Association of Colleges. The author would like to thank the Agriculture team at the College for the enthusiasm and speed with which they incorporated lean management principles into their courses. She would also like to thank Annette McDonald, Head of Commercial Services and Projects at the College, without whom this project would not exist.

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CONFERENCE PAPER

DOI: 10.5836/ijam/2017-06-134

Is the "F Word" an option for Brazilian farmers? The place of forestry in future integrated farming systems

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ABSTRACT

This study analyses the economic viability of forestry in integrated farming systems (IFS) in Brazil. A 12-year cash flow was built with both experimental data and estimates for three IFS in the Savannah region: ICL (crops + cattle); ICLF1 (ICL + 227 eucalyptus trees/ha); and ICLF2 (ICL + 357 eucalyptus trees/ha). Investment analysis showed all IFS were viable, but ICL was more profitable than ICLF, due to occasional high crops and beef prices and low wood prices in 2016. In extreme scenarios, i.e. all commodities prices were high (SCE I) or all low (SCE II), results remained the same. However, an alternative, most likely, scenario (SCE III) showed ICLF were more economically recommended than ICL, as beef and crop prices dropped and wood prices increased, which is expected because of commodities price volatility. Thus, the introduction of forestry in future IFS is economically viable, although market risks remain. Further adoption of IFS with trees relies on innovative and follower farmers, with strong support of R&D, technology transfer programmes and IFS policies.

KEYWORDS: ABC Plan; agroforestry; economic analysis; integrated crop-livestock-forestry systems; sustainable farming systems

1. Introduction

Brazil has become a major player in the world agricultural commodities market, historically developing forestry, crops and pasture under large monocultures. This production model has been efficient, from a supply perspective, given the joint expansion in area and productivity. Martha Junior, Alves and Contini (2012) demonstrated that, between 1950 and 1975, productivity in Brazil explained only 14% of the beef production growth, while pasture expansion accounted for 86%. Between 1996 and 2006, land-saving technologies allowed for major productivity gains, with 122% increase in beef production, despite reductions in total pasture area. The freed land was devoted to sugarcane, soybeans and other crops.

Despite this productivity growth, marginal gains of further technology intensification tend to decrease. Pasture degradation, crops pests and diseases, and other monoculture-associated problems have evidenced some of these farming models weaknesses, making room for consideration of new, more integrated and sustainable, farming systems.

Sustainable farming systems is a great challenge for the agricultural sector. Increasingly, integrated farming systems (IFS) have been in the spotlight given their potential to meet this challenge. IFS, in addition to promoting sustainability, may result in rapid and significant increases in meat, grains and wood supply altogether. Oliveira *et al.* (2014), for instance, showed an integrated crop-livestock-forestry (ICLF) system with 357 trees/ha obtained carrying capacities between 0.8 and 1.0 animal unit per hectare (AU/ha), similar to the Brazilian average. Diversification using IFS is possibly the major paradigm shift in Brazilian agriculture, since the green revolution in the 1960's.

IFS have been long known and practiced worldwide, but usually associated with small-scale production (e.g. Rana, 2015). In Brazil, however, the uptake has increased mostly among large-scale commercial farms, where conservation practices have been successfully carried out for decades. A survey with 7,909 farmers indicated around 11.5 million hectares (Mha) of IFS in Brazil (Embrapa, 2016), mainly established in the following states: Mato Grosso do Sul (2.0 Mha); Mato Grosso (1.5 Mha); Rio Grande do Sul (1.4 Mha); Minas Gerais (1.0 Mha); and Santa Catarina (0.68 Mha). The IFS in use involve different combinations of crops, livestock and forestry. Among cattle farmers using IFS, 84% adopt crop-livestock (ICL), 9% combine crop-livestock-forestry (ICLF), and 7% use livestock-forestry integration (ILF). Among crop farmers using IFS, 99% adopt ICL (Embrapa, 2016). Given the great uncertainties and still underdeveloped

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support systems for IFS, farmers using such systems are possibly innovators and early adopters, as Rogers (2003) proposes. They help "translating" technologies from research centres to commercial environments (Garb and Friedlander, 2014; Pereira *et al.*, 2016), and are usually less averse to risk than other farmers. They are, therefore, crucial, for the technologies diffusion process.

Considering the potential area of 67.8 million hectares (Mha) for IFS adoption in Brazil (Balbino, Barcellos and Stone, 2011), there is plenty of room for further developments. However, changing farmers' mind-set and practices, from production specialization to diversification combining crops, livestock and forestry altogether is a difficult task. Costa *et al.* (2014) identified some limiting factors for generalised adoption of IFS:

- Farmers' short-term vision, prioritizing immediate gains;
- Specialization enables economies of scale;
- Change in usual infrastructure and machinery to meet the new products requirements;
- The increased carrying capacity resulting from improved pastures may require further purchase of cattle, even by ranchers;
- Need for management skills and information technology, given the higher complexity of IFS (see Almeida *et al.* (2015) for further comments);
- Minor concerns about social and environmental issues, possibly because they provide no direct compensation;
- Lack of initiative and risk-taking behaviour among traditional farmers.

Additionally, different farmer types have different sets of goals and values, which can also limit, or facilitate, technologies uptake, including those involved in IFS. Pereira *et al.* (2016), for instance, claimed that nature-oriented farmers are possibly keener on sustainable practices, including IFS, than strongly production-oriented farmers.

To encourage further adoption of IFS in Brazil, public policies and private sector initiatives are underway. The Brazilian government launched the National Plan for Low Carbon Emissions in Agriculture, the so-called "ABC Plan", as part of a strategy to meet its voluntary commitment at COP 15 to reduce greenhouse gas emissions (GEE) by 36–38% by 2020 (Mello, 2015). The Plan, implemented in 2010, promotes the adoption of IFS, degraded pasture recovery practices among others, by making rural credit available for farmers at "low" interest rates (7.5% to 8% *per annum*)[3]. In 2012, the Brazilian Agricultural Research Corporation - Embrapa - launched the "ICLFS Fostering Network", a public-private partnership to promote and transfer IFS technologies to farmers (Embrapa).

An example in the research field is the "Pecus Network" project, which has been studying beef production systems, as monoculture or in IFS, capable of mitigating GEE (CPPSE, 2011). Many other studies have shown the biophysical advantages of using IFS, such as improvement in microclimate and animal welfare (Karvatte Junior *et al.*, 2016), in pasture quality (Almeida *et al.*, 2014), systems resilience (Jose, Walter and Kumar, 2017), crops, beef and wood yields (Franchini *et al.*, 2014). However, most fail to present economic analysis of empirical data (Lazarotto *et al.*, 2009; Martha Junior, Alves and Contini, 2011).

Nonetheless, further adoption of these novel IFS requires more information about their economic performance, reason why this study focusses primarily on this issue. Such concern is particularly important for IFS with trees, given their long-term horizon and associated uncertainties. Moreover, unlike the crop-livestock integration, forestry is a foreign activity for crop and beef farmers. The objective of this study, therefore, is to fill this void and to evaluate the economic viability of introducing forestry in IFS in Brazil.

2. Methods

Since 2008/2009[4], three integrated systems have been studied in Campo Grande/MS, Brazil, as alternatives to recover degraded pasture in Savannah-like regions, in Central Brazil: ICL (crops + cattle); ICLF1 (ICL + 227 trees/ha); and ICLF2 (ICL + 357 trees/ha). The experiments consisted of three consecutive four-year cycles: one year with crop followed by three years with pasture, with or without trees (*Eucalyptus grandis* × *E. urophylla* hybrid). Eucaliptus is the main planted tree in Brazil, covering 5.6 Mha of the total 7.7 Mha of planted forests (IBA, 2017).

The experiments were originally designed to evaluate the effect of tree density and spatial arrangements on crop and beef production, with trees planted in single rows, with 2 m between trees and 22 or 14 m between rows, in ICLF1 and ICLF2, respectively. Crops, followed by pasture, were sown between tree rows.

An experimental area of 18 ha (6 ha per IFS) was prepared, subsoiled and cultivated twice in September/2008. In November/2008, 3 t/ha of limestone, 1 t/ha of gypsum, preplant herbicides and 300 kg/ha of 05-25-15 (Nitrogen-Phosphorous-Potassium (NPP)) fertilizer were applied. Soybean was cultivated from November/2008 to March/2009, associated, or not, with trees (i.e. ICLF). After soybean harvest, palisade grass (*Urochloa brizantha* Piatã) was sown. Once the trees reached 7 cm in diameter (May/2010) and were resistant to cattle rub, Nellore heifers (160 kg) were introduced in all IFS. Meanwhile, the systems produced hay (2009/2010 season) (see Oliveira *et al.* (2014) and Pereira *et al.* (2014) for further details).

The second cycle (2012/13–2015/16) repeated the first cycle (2008/09–2011/12), but introduced annual pasture fertilization with 05-25-15 NPK (300 kg/ha) and urea (110 kg/ha), as the carrying capacity was reducing.

The third cycle (2016/17–2019/20) has just started and repeats the second cycle, but with corn instead of soybean as a crop. Recently, the thinning of 67% of ICLF2 reduced the number of trees from 357 to 118 trees/ha; in ICLF1, trees/ha diminished from 227 to 113 (50%). The spatial arrangement also changed from 22 x 2 m to 22 x 4 m in ICLF1, and from 14 x 2 m to 28 x 4 m in ICLF2. Cattle weight and grazing period were controlled within each IFS to estimate the annual average weight gain. Varying stocking rates were applied to keep forage availability around 2,000 kg Dry Matter (DM)/ha ("put-and-take" system). Table 1 presents all IFS yields and the average commodities prices in 2016.

Amongst IFS, the beef production reduced as the density of trees increased (Table 1), and over time for ICLF1 and ICLF2. In contrast, it increased 30% for ICL. Equal beef production was estimated for ICLF1

[3] The current Brazilian interest rate is 12.25% *per annum*.

[4] The agricultural year starts on the 1st of July and finishes on 31st of June of the following calendar year.

Table 1: Commodities yield and output prices[1] from IFS (2016)

Commodities	Yield (unit/ha)			Prices (USD/unit)[2]
	ICL	ICLF1	ICLF2	
Hay	t			
Palisade grass hay (Year 1)	4	4	4	47.83
Cash Crops	t			
Soybean (Year 1)[a]	2.10	2.10	2.10	377.67
Soybean (Year 5)[a]	2.94	2.28	2.04	377.67
Corn (Year 9)[b]	5.70	4.80	4.80	167.33
Beef (annual averages)	kg of live weight (kg LWT)[3]			
Cycle 1 production (yrs 2–4)[a]	567 (1.0)	475 (0.8)	355 (0.6)	1.42
Cycle 2 production (yrs 6–8)[c]	737 (1.3)	475 (0.8)	323 (0.5)	1.42
Cycle 3 production (yrs10-12)[b]	737 (1.3)	425 (0.7)	425 (0.7)	1.42
Wood	m^3			
Charcoal (thinning – year 8)[a]	–	81.5	193	10.04
Charcoal (logging – year 12)[b]	–	130	153	10.04
Timber (logging – year 12)[b]	–	35	38	28.68

[1] Average exchange rate (2016): 0.287 BRL:USD (www.xe.com/pt/currencytables/).
[2] The measuring unit is shown on the yield columns (e.g. USD 28.68/m^3 for timber).
[3] In brackets, an index shows the proportion of beef production using ICL yield in the first cycle as reference (1.0).
[a] Experimental data; [b] Estimated data; [c] Partial experimental data (years six and seven; year eight data are being processed).

and ICLF2 in the third cycle, given their similar number of trees/ha after thinning. Between the first and second cycles, soybean production increased for ICL and, to a lesser extent, for ICLF1, but reduced slightly for ICLF2, which had more trees competing for resources, corroborating Franchini *et al.*'s (2014) findings. In the third cycle, corn production estimates considered a more favourable environment for crops after trees thinning (i.e. less competition for resources), although they remained below ICL estimate. Wood production increased with tree density.

Considering the experiments long-term nature, a 12-year cash flow was prepared using all the above parameters. Additionally, an investment analysis was carried out, using an annual discount rate of 10%[5] to determine the net present value (NPV), benefit-cost ratio (B/C) and discounted payback period in years (PBK) for the three IFS (i.e. Reference Scenario). Given ICLF cash flow contained more than one signal reversal, the internal rate of return (IRR) was inconsistent (Rae, 1994), and, thus, disregarded.

We assumed most farmers have the necessary infrastructure to implement IFS and, thus, additional machinery and buildings were disregarded. We used machinery hire prices, defined for several farming operations and available at Richetti (2016). The cash flow included only running costs and, consequently, the systems implementation costs (season 2008/09) consisted of seeds/seedlings, fertilizer, chemicals and all services. Labour costs were priced at 14.34 USD/day. Beef operational costs were estimated at 0.75 USD/kg LWT. Given beef revenue considered only the additional meat produced within each IFS, production costs were assessed accordingly, not including animal purchase. Additionally, the cash flow included ant control, thinning (year 8) and logging (year 12) costs.

[5] We used the Brazilian government ten-year bond returns (around 10%) as opportunity cost for capital, considering IFS long-term. Alternatively, savings account rates (6% *per annum*) can be used.

Table 2: Implementation costs (USD/ha) of pasture, crops and trees under three IFS, in Mato Grosso do Sul state, Brazil, season 2008/2009

Inputs	ICL	ICLF1	ICLF2
Seeds	112.61	112.61	112.61
Tree seedlings	–	29.61	46.67
Lime/Fertilizer	330.94	390.88	423.57
Chemicals[1]	51.10	74.36	81.89
Subtotal	494.65	607.46	664.75
Services			
Labour	28.68	54.49	67.39
Machinery	32.15	346.08	379.94
Transport	19.75	19.75	19.75
Subtotal	374.57	420.32	467.08
Total	**869.22**	**1,027.78**	**1,131.82**
Cost index (ICL = 100)	100	118	130

[1] Includes herbicides, pest and disease control.

Investment analysis of alternative scenarios (Olson, 2011) were undertaken varying commodities prices, all else remaining the same, to evaluate how IFS affects profitability. In scenario I (SCE I), wood prices increased by 25%; in scenario II (SCE II), beef and cash crop prices reduced 15% and 20%, respectively; and scenario III (SCE III) combined SCE I and SCE II. These scenarios simulate possible market conditions, given prices cyclical waves.

3. Results

As expected, implementation costs increased with the increase of tree densities, being 19% and 30% higher in ICLF1 and ICLF2, respectively, than in ICL (Table 2). This result may help explaining the lower adoption of IFS with trees compared to crop-livestock integration found in the survey mentioned earlier (Embrapa, 2016).

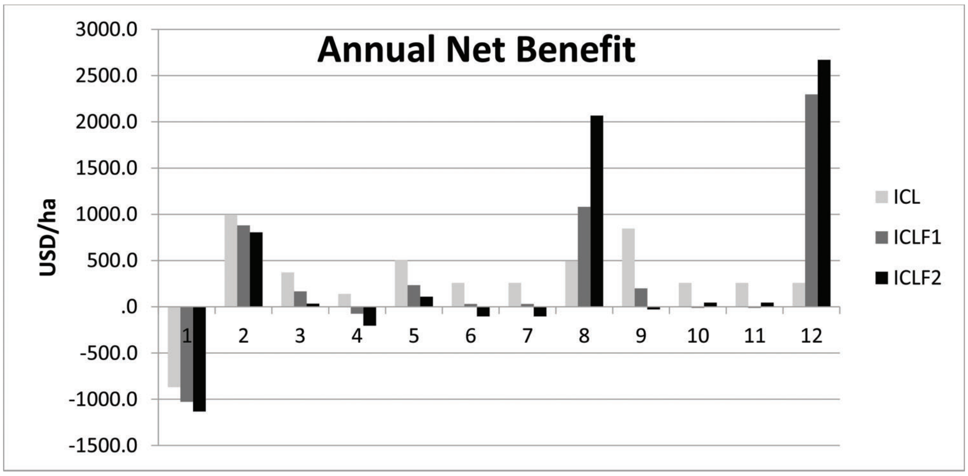

Figure 1: Cash flow of three IFS in Mato Grosso do Sul state, Brazil

Table 3: Investment parameters of three IFS, in Mato Grosso do Sul state, Brazil (2016)

Parameters	ICL	ICLF1	ICLF2
NPV (USD/ha)	2,047.44	1,493.99	1,448.60
B/C	3.36	2.37	2.02
PBK (yr)	0.96	3.90	6.54

This cost could be prohibitive for some farmers, particularly small landowners or those in need of further machinery or infrastructure to start IFS.

The annual net benefit (NB = Receipts – Costs) was also remarkably different across the farming systems with and without trees (Figure 1). ICLF1 and ICFL2 benefitted from major wood sale in years eight and 12, after the trees thinning and logging, respectively. In contrast, ICL presented the most even NB across the years, and often higher, than both ICLF.

Figure 1 also shows that both ICLF presented negative net results in some years due to the systems continuing costs, including ant control and pruning, which were not always timed with revenue from cattle and/or crop. This can pose a threat to farmers' cash flow position and they must be prepared for periods where, eventually, costs can exceed receipts.

An investment analysis brought further insights on relevant parameters for farmers' investment decisions. All three farming systems were economically viable in the Current Scenario (CRT-SCE), given their positive net present value (NPV) and Benefit/Cost ratio greater than one (Table 3).

In the CRT-SCE (Table 3), IFS with trees were economically less interesting than the ICL. ICL had higher NPV and benefit-cost ratio (B/C), and shorter payback period (PBK) than ICLF. Between ICLF1 and ICLF2, the former performed better than the latter, suggesting that the less trees in the IFS, the better the economic performance, *ceteris paribus*.

Nonetheless, these results should be interpreted with caution and within their context. At high discount rates, i.e. 10% p.a., ICLF systems are "penalised" for providing economic benefits mainly in the long term. Additionally, in 2016, crops and beef prices boosted, while prices for wood-based products reduced (GWMI, 2016). Therefore, the IFS more reliant on timber were doubly impacted in this scenario: (1) the reduction of wood prices reduced the estimated revenue from forestry (i.e. the higher number of trees, the higher the reduction in relative revenue); and (2) ICLF did not fully benefit from crops and beef prices increase due to their lower yields (Table 1). Moreover, farmers using ICLF can delay the trees harvest for a few years, increasing the chances of better prices and, thus, of improved returns. Our research protocol, however, did not allow for this alternative.

Given price volatilities, three alternative scenarios were then analysed: higher wood prices (SCE I); lower beef and crops prices (SCE II); and, SCE III as a combination of SCE I and SCE II (Table 4).

The sensitivity analysis suggested that IFS, with and without trees, remained economically viable (NPV $>$ 0 and B/C $>$ 1), even under low commodities prices (i.e., SCE II). However, different scenarios affected more, or less, particular IFS, often changing the most profitable system. Results indicated better economic performance for ICL in extreme conditions: when all commodities prices were high or, low. The analysis of SCE III, which combined low prices for crops and beef with high prices for timber, showed both ICLF performed better than ICL, in sharp contrast to CRT-SCE. For some scenarios, the payback period was over six years, which could bring financial risks to farmers low in equity, should they face a long period of accumulated negative balance.

4. Discussion

An analysis of Tables 3 and 4 suggests that the economic performance of IFS may vary significantly under different scenarios of output prices. Martha Junior, Alves and Contini (2011) argue that the economic performance of IFS is a function of input/output relative prices, which our results corroborate. At given input prices, and in the context of high beef and crops prices, ICL usually performed better than ICLF, also favoured by the high discount rate used in this study. At higher wood prices, ICLF performed better (SCE I) and even, exceeded ICL (SCE III), but subject to relative beef and crop prices.

These prices were peaking, in 2016, resulting in rather unrealistic long-term scenario (CRT-SCE), since grains returns are highly volatile (Lazarotto *et al.*, 2009), given commodities cycles, public policies etc. To address this

Table 4: Investment parameters (NPV, B/C and PBK) under three scenarios of changing commodities prices for IFS

Parameters	SCENARIO I			SCENARIO II			SCENARIO III		
	ICL	ICLF1	ICLF2	ICL	ICLF1	ICLF2	ICL	ICLF1	ICLF2
NPV (USD/ha)	2,047.4	1,777.37	1,870.69	915.4	666.2	742.2	915.4	949.6	1,164.3
B/C	3.36	2.63	2.27	2.05	1.50	1.42	2.05	1.70	1.64
PBK (yr.)	1.0	3.9	6.4	1.7	10.1	10.2	1.7	6.8	6.8

situation beef and crop prices reduced in scenario II. However, the low timber prices prevented ICLF from improving its performance. The 25% increase in timber prices benefited ICLF in SCE I, but did not ensure, by itself, a result that surpassed ICL, given beef and crops high prices. Under this optimistic scenario, all IFS achieved their best economic performances, with similar NPVs for ICLF1 and ICLF2, but lower than ICL results. Scenario III simulates 2014, when timber market was heated and beef and crops prices were low. Under these conditions, the more trees in the IFS, the higher was the profitability, corroborating Pereira, Costa and Almeida's (2015) findings.

Costa *et al.* (2012), Silva (2014) and Pereira *et al.* (2015) also studied the IFS[6] presented here and found similar results to those in SCE III. Pereira *et al.* (ibid), for example, showed ICLF2 achieved a NPV 1.5 times higher than ICL, which had the lowest performance of all IFS. This is in sharp contrast to the CRT-SCE, using current data. The prices in 2014 were USD 0.99/kg LWT, USD 282/t, USD 35.27/m^3 and USD 13.19/m^3 for beef, soybeans, timber and charcoal, respectively. Compared to 2016, these prices increased by 52% and 34% for the former two and decreased by 19% and 24% for the latter two.

The question remaining to be answered is whether the current scenario (CRT-SCE) is probable to replicate or scenarios I, II or III likely to occur (or new scenarios considered). From January to February/2017, beef and soybeans average prices have already dropped to USD 1.38/kg LWT and USD 357,33/t, respectively, with corn prices remaining stable (CEPEA, 2017; a, b, d). In contrast, average wood prices reached USD 32.71/m^3 in March/2017 (CEPEA, 2017 c), suggesting markets are moving towards SCE III.

Our results suggest the long-term market trends for the wood-based products are important for farmers thinking of introducing forestry in IFS. The Brazilian economic crisis, in 2015, resulted in drops in wood sales (5%) and prices (GWMI, 2016). Despite uncertainties around further developments of the wood industry, Brazilian economy started to recover. Inflation is controlled, investment levels increased and a 0.5% economic growth rate is expected for 2017, creating an inviting environment for wood demand to grow. The pulp and paper industry, for instance, is expanding and benefiting from major international trade (The Economist, 2016). Other wood-based products exports increased 21.6% between 2015 and 2016, reaching US$ 250 million (GWMI, 2017). In 2017 (Jan/Feb), wood panels production and exports increased 8.5% and 40%, respectively, compared to Jan/Feb 2016 (IBA, 2017).

Beyond the commodities markets, other initiatives are needed to further support the adoption of forestry in IFS. Credit through the government "ABC plan" is readily available and the uptake is increasing (i.e. over 25,000 contracts, between 2010–2015) (Mello, 2015). New steel mills and other investment projects in Brazil will increase the demand for wood-based products, although, at unknown pace. Other initiatives, such as the Carbon Neutral Brazilian Beef (CNBB) protocol may add value to IFS products, including timber. CNBB allows for the design of premium payments for certified wood and/or beef under silvopastoral or agrosilvopastoral systems, following welfare and good practices guidelines, so that trees neutralise the cattle methane emissions (Almeida *et al.*, 2016). Planted forests also contribute to reduce the pressure for deforestation, providing relevant environmental services (e.g., avoided GEE). Environmental services market in Brazil is only incipient, but growing, supported by the country's intention to establish itself as a "world reference in carbon trade" (GEF, 2013; p. 14).

Given the uncertainties still present in IFS, with unclear markets for potential added-value products and limited economic studies, the diffusion of future IFS, particularly with forestry, seems to rely primarily on innovative, perhaps least-averse-to-risk, farmers in Brazil. Lead farmers are relevant to the innovation system, as they display technologies to other potential adopters (followers) (Pereira *et al.*, 2016). Further economic research considering changing input/output prices and yields, and risks assessments are required. Policies to minimize forest investors' risks must be prioritised to support farmers introducing trees in IFS.

5. Conclusions

Our results, and other IFS economic assessments, indicate, at given yields and input prices, the relative output prices seem to determine the most profitable farming system. The number and spatial arrangements of trees impact investment parameters, given the trade-offs between long-term benefits, and implementation and running costs. These must be assessed accordingly.

Generally, the introduction of forestry in future IFS in Brazil is economically viable, as long as the wood industry is solid. Since farmers make less than optimal decisions, due to lack of full knowledge of possible scenarios (Lazarotto *et al.*, 2009), all studied IFS are economically acceptable. Further introduction of trees in IFS relies on innovative and follower farmers, with the support of R&D, technology transfer programs and IFS policies.

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[6] Except that soybean was the crop in the three production cycles.

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Acknowledgements

This article was presented as a peer-reviewed paper at the 21st International Farm Management Congress, Edinburgh, United Kingdom, July 2017 and is reproduced by kind permission of the International Farm Management Association. This study is part of a Research Project sponsored by Embrapa under the grant number 02.13.11.003.00.03. The authors are grateful for the comments of anonymous reviewers on an earlier version of the article. The participation at IFMA Congress was sponsored by the 'ICLFS Fostering Network', which the authors are thankful for.

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CONFERENCE PAPER

DOI: 10.5836/ijam/2017-06-141

Pastoral farming on the Qinghai-Tibet Plateau

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ABSTRACT
We report on pastoral farming systems in Henan County (altitude 3600 metres) within the Sanjiangyuan (Three-River Headwaters) Region of the Qinghai-Tibet Plateau. Our information comes from in-depth interviews of 16 pastoral farming families, one focus group, plus discussions with key local informants. Traditional nomadic pastoral farming systems are in transition to semi-nomadic, with permanent housing and associated animal shelters for much of the year but still with grassland tent-living by pastoral farming families in summer. Yaks and Tibetan sheep are the dominant livestock. Livestock products in Henan include meat, milk, butter and cheese (*qula*) from yaks, and meat, wool and skins from sheep. Yak dung is the main source of fuel for cooking and heating. Dung is also a commercial product. Yaks calve in spring, typically having their first calf at four years of age and then calve every second year. Sheep lamb in autumn, typically having their first lamb at three or four years of age. Predation by wolves is a major issue with sheep. Overall animal productivity is low. Sustainability issues are a major concern due to ongoing nutrient removal from dung and animal products, combined with high rodent plateau pika (*Ochotona curzoniae*) populations and general overgrazing.

KEYWORDS: Qinghai-Tibet Plateau; semi-nomadic pastoral farming systems; Henan County; yaks; Tibetan sheep

1. Introduction

The Qinghai-Tibet Plateau covers an area of 2.6 million square kilometres. It comprises grassland, desert and high-altitude mountains, bounded on four sides by the Himalayas, Pamirs and Karakoram, Kunlun and Qilian Mountains, plus Hengduan Mountains. To the east, the Plateau flows into mid-level valleys that feed into the plains of China. Most of the Plateau lies within the current borders of China, spanning 31 degrees in longitude and nearly 25 degrees in latitude (张镱锂 *et al.*, 2002). The grassland area comprises 1.7 million square kilometres and has been the traditional home of Tibetan nomadic herders (Miller, 1999, Miller, 2000).

Our interest within this paper relates to the Sanjiangyuan (三江源, Three-River Headwaters) Region, an area of 302,000 square kilometres on the north-eastern part of the Plateau within Qinghai Province. The traditional name for this and surrounding regions is Amdo. The Sanjiangyuan Region is where the three major rivers of China (the Yellow, Yangtze and Mekong (known as Lancang in China)) all arise. Accordingly, it is perceived as having major environmental significance for all of China. Having designated the region as a nature reserve, the Government requires that all production systems use organic methods, with no use of chemical fertilisers. There are some 556,000 people living within this Sanjiangyuan Region, with over 90 percent of them being of Tibetan ethnicity (China Insitute of Water Resources and Hydropower Research, 2016).

The human population of the Sanjiangyuan Region has increased rapidly over recent decades, as China's One-Child Policy was never applied to the homelands of ethnic minorities such as the Tibetan people. The region also has significant problems related to rodent populations. Accordingly, there are major issues of degradation and sustainability, with some debate as to the fundamental causes (Cao *et al.*, 2013, Goldstein *et al.*, 1990, Harris, 2010, Miller, 1999, Miller, 2000, Ptackova, 2011, Waldron *et al.*, 2010, Wang *et al.*, 2016, Yan *et al.*, 2011, Yeh, 2003, Yeh, 2005).

For the people who live here, the farming systems are pastoral, with an almost total focus on yaks and Tibetan sheep, and are heavily constrained by the short growing seasons. Crops have typically only been planted in very small areas adjacent to houses as limited winter supplements for livestock.

There has also been an ongoing process of sedentarisation, where the local people are assisted with the building of permanent houses either within townships or on farms. Families have long-term use-rights over specific land areas, after 1981, when the Household Responsibility System was introduced, but the land areas held by a farming family are not always contiguous.

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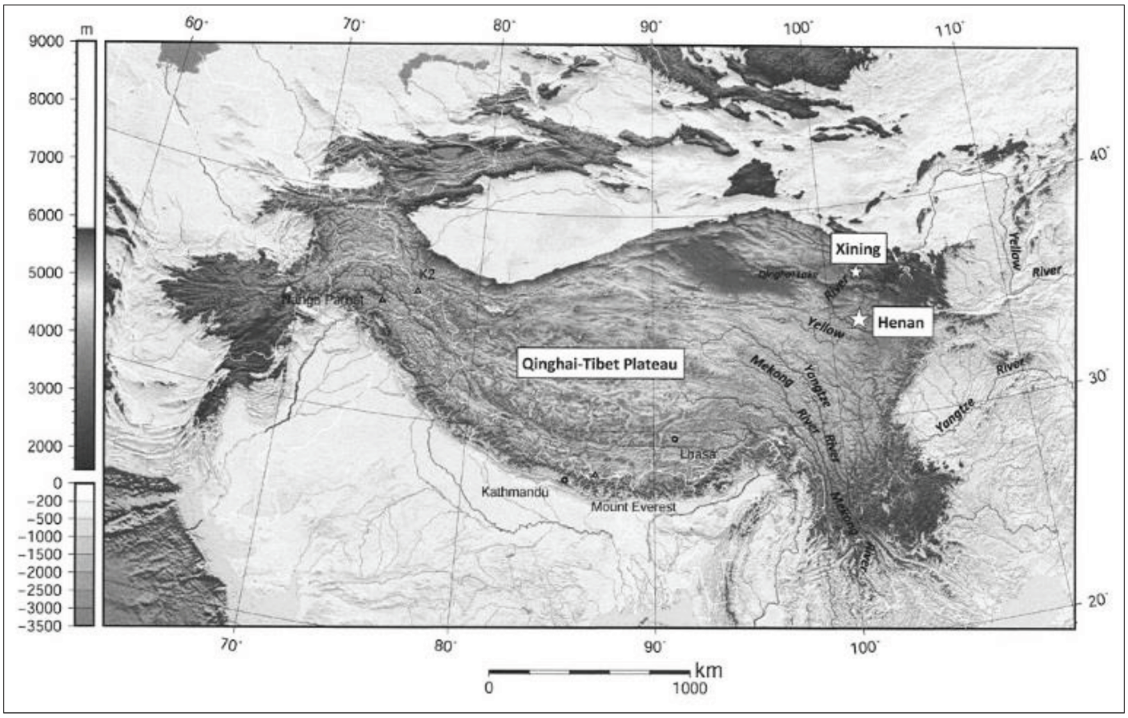

Figure 1: Map of Qinghai-Tibet Plateau (adapted from public commons)

Accordingly, and also due to a well-observed tradition, although most farming families now have a permanent house, they still live in tents out on the grasslands during summer.

Our particular interest here is in the County of Henan, within Huangnan Prefecture in the east of Sanjiangyuan Region (Figure 1). We have been visiting here informally since 2012. Since 2015, we have been part of a sustainable systems research project between Lincoln University in New Zealand and Qinghai University in China, with trial sites in both countries, and funding from both the New Zealand and Chinese Governments (Project numbers MBIE LINX1404 and MOST 2015DFG31870). Our broader aim relating to the Qinghai-Tibet Plateau is to try to first understand and then address issues of sustainability, within a very complex environment. However, in this paper we limit ourselves to describing and interpreting aspects of the pastoral system as we have identified within Henan County.

2. Methods

Our approach lies within the qualitative paradigm whereby we have sought to ask 'what', 'how' and 'why' questions about the phenomena under study. Our approach has been influenced by many writers within the qualitative paradigm, but particularly by elements within grounded theory (Bowen, 2006, Charmaz, 2006) and also by the inductive-led theory building principles of Eisenhardt (Eisenhardt, 1989, Eisenhardt and Graebner, 2007). In essence, the approach has been to observe and to let the informants 'tell their stories' of actual events together with their thoughts, and then to identify emergent insights from the data. It is important to note that this qualitative research philosophy encompasses the use of numeric data, wherever it is available, as part of the descriptive and interpretive process.

Much of the pastoral farming information that we present has come from semi-structured interviews of 13 farming families undertaken in the summers of 2015 and 2016, then another three farming families and one focus group in the spring of 2017. The families were chosen conveniently – wherever we saw a farming family on the grasslands, or smoke coming from a tent, we would introduce ourselves to these people and ask if we might interview them. There were no refusals, and the interviews typically took place within their summer tent-homes. For the focus group, we used our local contacts to pre-arrange a meeting time and place, and then conducted the interview. Because the farmers typically speak Tibetan but not Chinese (Mandarin), we used a local bilingual person (whom we had previously come to know) to interpret from Tibetan to Chinese. Although we had a set of open-ended questions to guide the interviews, the aim was to let them flow as conversations wherever possible. The interviews were undertaken without any official being present and most were recorded digitally, with subsequent transcription thereof in Chinese.

We observed a male-dominated family environment. For the farming-family interviews, often both genders of the family were present, but the women said almost nothing unless specifically addressed. On one occasion, when a woman was present for part of the interview in the absence of men, it was evident that she had equivalent farming knowledge. For the focus group that we pre-arranged, only men turned up for the meeting.

Our interpretive assumption is that our interviewees, both male and female, had minimal literacy skills, and there was no evidence of any record-keeping or written materials. In contrast, the children of these families that we met were literate and had Chinese as well as Tibetan language skills.

Most of the on-farm and focus-group interviewees were aged between 25 and 50. We consider this reflects early marriage (with women traditionally marrying at about

16 years of age), short generation intervals, and with older people having retired to Henan county centre where they also look after the school-age grandchildren.

The information we report here is also influenced by our own observations on the Qinghai-Tibet Plateau between 2012 and 2017, together with discussions we have had with local business people and officials, who have always shown willingness to answer our probing and at times naïve questions.

3. Results

The locale

Henan County is some 300 km south of Xining, the capital city of Qinghai Province. Whereas the majority of the population of Xining (altitude 2,275m) is Han Chinese, with smaller groups of various ethnic minorities, up on the grasslands the majority of the people speak Tibetan, wear Tibetan clothing, observe Tibetan customs and follow Tibetan Buddhism. Within Henan County itself, although all of these behaviours accurately describe the people, they actually consider themselves Mongolian, and hence also celebrate Mongolian festivals. Our local contacts informed us that their Mongolian heritage comes from the time of Genghis Khan through to his grandsons and thereafter, when Henan County was a staging area for Mongolian invasions heading elsewhere across the Plateau.

Henan County lies in the headwaters of the Yellow River, at an altitude of approximately 3,600 metres. Annual rainfall averages 600 mm and is summer dominant. Our observations are that pastures lie dormant until early May owing to low temperatures, and that the growing season is essentially over in September, primarily due to declining temperatures and soil moisture having been exhausted. Within Henan County, the population increased from 25,644 in 1991 to 39,508 in 2014 (1.9 percent compound growth per annum); during this time the farming population increased from 21,868 to 32,977 (1.8 percent compound growth per annum) (河南蒙古族自治县统计局, 2015, 河南蒙古自治县年鉴编委会, 2004).

The pastoral system

Our observations are that pastures are grass and herb dominant in Henan, and legumes make minimal contribution to livestock feed supply. Pasture degradation from rodents, in particular the plateau pika (*Ochotona curzoniae*), is very obvious. The farmers consistently stated that pasture quality had declined during their lifetime.

Land areas depend on initial family allocations in about 1995 (following multi-family allocations in about 1985) and reflect the family size at that time. Most of our interviewee families have access to between 1000 and 2000 mu (1ha = 15 mu) on 50- to 70-year leases from the Government. Some also rent additional land from community members, typically for two- to three-year periods, but with some longer-term leases.

The farmers typically considered blocks within their allocated areas as being either for winter/spring, summer, or autumn. In some cases, the categorisation is a function of altitude and also whether it lies to the sun. However, a key determinant can also be proximity to the permanent winter house and associated livestock shelters. When livestock are on summer pastures, farmers need to be nearby during the night, and animals are corralled with temporary fencing as a predation-avoidance strategy.

The land areas held by each family typically have external fences. Much of this fencing has occurred within the last 20 years, with major subsidies from Government. This reflects the official policy that 'sedentarisation' is the path that should be followed, which reflects the philosophy of avoiding "tragedy of the commons". Some families also have limited internal fencing of up to four blocks, and practice some level of rotational grazing.

Most land is grazed by individual families, although families sometimes share summer land. One farming family worked within a communal farming system of 23 families. They said they were the only such group of communal farmers in the prefecture, and that they did it by choice, as they liked being able to share the work and enjoy the community spirit. All families within this group accept and obey a communal decision of setting a limit to the number of livestock that can be returned to the communal winter pasture, for sustainability purposes.

Livestock and livestock products

All farmers have yaks and most have Tibetan sheep. The yaks are farmed both for their meat and milk. The sheep are farmed mainly for meat, with wool apparently being a declining product. Sheep skins are sometimes used for clothing, particularly for making traditional Tibetan costumes. It also became evident during the interviews that dried yak dung is an important product. The dung is collected from the night corrals, and also at times from paddocks. It is then dried and sometimes bagged. Given that this altitude is above the tree line, farming families typically use yak dung as their only source of energy for cooking and warmth. They also supply the dung to the grandparents living in the county centre, and then sell surplus dung that has been collected to be further processed into organic fertiliser and sold on the lowlands. Some families reported selling up to 200 bags of dried dung per year, each of 25 kg. Combined with the lack of fertiliser-use due to the official mandate of maintaining organic production, we see a significant loss of nutrient from the Plateau from this widely practiced removal of dung.

Milking yaks are typically milked twice per day. Both the milking and subsequent processing of the milk is always women's work. First, the animals are herded and tied to a pegged rope. The calf is initially given access to stimulate milk let-down, and is then pushed away. Milking is by hand, with milk drunk fresh, and also processed into both cheese, locally known as *qula*, and butter. Female yaks often remain in lactation for over a year, from calving in the first spring through to the end of the second summer. But her milk may not always be used for human consumption during the winter, depending on the conditions of the female yak and her calf.

Yak herds ranged from 50 to 200, and sheep flocks typically ranged from 10 to 350 in size. Invariably, farmers would state their inventory numbers in units of 10, reflecting uncertainty as to precise numbers, although more precise numbers were stated for sales.

The most important period of slaughter is around November, as winter closes in, and while animals are still in good condition. Farmers will also slaughter a few animals for themselves to last through the winter.

We learned that the outdoor meat storage facility is made with a dung and water mix, which was said to provide good ventilation and insulation.

Animal productivity

Animal productivity is low. Yaks typically calve in spring, first at four years of age, and thereafter every two years, although some may calve in two consecutive years under good pasture conditions. Female yaks may be retained for 10 years or more. Males are sold between two and seven years of age. Sheep are mated to produce lambs in the autumn after returning from the summer pastures, with first lambing at the age of three or four. Predation from wolves is a major issue with sheep. Also, in harsh winters sheep are more likely than yaks to succumb to cold and underfeeding, hence often being kept in covered shelters overnight. We estimate that overall mortalities may approach 10 percent per annum and possibly more, particularly for sheep. Given that animals aged less than one year typically comprise less than 20 percent of the total herd and flock for each family, then we estimate that annual offtake (births minus mortalities) may be no more than 10 percent of the total inventory, and on occasions lower.

Many farmers also have 'Buddha' yaks and sheep. These animals are dedicated to Buddha, often as a sign of offering and redemption of ailment of family members. Although the milk and wool from these animals can be harvested and used, they are never killed, eventually dying of old-age or other natural causes.

Livestock and product values

Livestock are always sold 'on the hoof' and values are only known on a per-head basis, with all sale transactions undertaken with cash. Prices vary considerably depending on supply and demand, but typical values for yaks are 3500 to 4000 RMB (1 USD is approximately 6 RMB). Adult Tibetan sheep are worth 600 to 1000 RMB and lambs are worth 300 to 400 RMB at one year of age. The dominant sheep breed is known as the *Oula* breed. They are large-framed, with adult sheep perhaps 60kg in live weight. We were informed that because all farmers are Tibetan Buddhism believers, who abstain from killing of lives wherever possible, they sell animals to mostly Muslim abattoirs and butchers, therefore take whatever price is on offer.

Livestock, and particularly yaks, are seen as a stock of wealth. In the Tibetan language, the word '*nor*' means both yak and wealth. Farmers appeared to want to hold onto as many livestock as possible. Additionally, farmers only use their bank accounts as repository for the annual Government subsidy payment, which they access using a bank card. The combined effect is that animals tend to be sold only when there is a need for cash.

Prices that farmers receive for milk products vary between products and also different times of year, largely due to supply and demand. Milk (approximately 7 percent fat, 5 percent protein) is worth about 8 RMB per kilo, but may be up to 10 RMB per kilo during winter, with yaks producing about 1.5 litres per day in the first year of lactation. Butter sells for approximately 50 RMB per kg and cheese sells for 20 to 40 RMB per kg, and again increasing in prices during winter when there is a shortage in supply. Dried dung, however, seems to remain a stable price over the years during our interviews, which sells for 7–8 RMB per 25 kg bag.

4. Discussion and Conclusions

The farming systems on the Qinghai-Tibet Plateau are under transition. One key factor driving the transition is that population has increased greatly over the last 50 years linked at least in part to improved health conditions, combined with higher birth rates than in the Han-dominant parts of China. Another key factor driving the transition is a Government policy of sedentarisation, which links to health, education and environmental management policies.

We note that livestock values and product values might seem high compared to many less developed countries. These values reflect not only that pastoral products are the sustenance of life and are highly valued by the locals, but are also in demand by a wider market on the lowland. For the farmers, we learned that there is no Tibetan word for 'vegetables', and some women told us they would not know how to cook them, or only learned how to cook them as they became accessible from the local markets. They also purchase some flour (barley or wheat) from the county centre, and use it as an important dietary component. The inclusion of wheat and vegetables, which were not part of the traditional nomadic diet, as we were informed, is a reflection of increased connection with the world beyond the Plateau.

We consider that Henan County at 3,600 metres altitude has superior pastoral conditions to many other parts of the Qinghai-Tibet Plateau, where altitudes of pastoral land may exceed 4000 metres. There are also some parts of the Plateau that have lower altitudes (down to approximately 3000 metres) than Henan, but rainfall typically becomes more limiting in those locales than in Henan. Also, our interviewees were typically living within 20 km of the county centre. As such, we are cautious of generalising specific pastoral findings more broadly across the Plateau. We note that the animal productivity is similar to that reported for the Qinghai-Tibet Plateau in a review by Long *et al.* (2008), but it is unclear as to the original sourcing of their production parameters, which are referenced back to a 1994 Chinese publication. We are not aware of any previous studies that have interviewed Plateau families in the way we have done here.

The greatest challenge to the current farming systems, which is the essence of the issues that emerged from our research and observations, relates to sustainability thereof. A key insight from our own work is the major loss of nutrients from the system through burning and sale of yak dung. Also, there is now considerable removal of livestock products from the Plateau down to major cities such as Xining. We saw yak products being sold in supermarkets in Beijing, which is about 1,700 kilometres by road from the Plateau. In contrast, there is no obvious entry of nutrients into the pastoral system beyond natural mineralisation. This lack of nutrient cycling contrasts to the traditional nomadic systems whereby products were consumed on the Plateau, and with this occurring within a nomadic lifestyle where even human excreta also returned directly to the pastoral system.

From a technical perspective, it is easy to identify that animal performance is constrained by inadequate nutrition, with much of the available feed being of low energy and protein. However, the implications of dealing with these issues within a bio-socio-economic system, and in a locale where people have lived for many thousands of years, albeit at much lower population levels, raise profound issues. We reflect that these issues of grassland sustainability are pervasive across much of the world's mountainlands, but with each region having its own specific biological and social environment. We are reminded of a phrase from American President Dwight Eisenhower in 1956, that "farming looks mighty easy when your plough is a pencil and you're one thousand miles from the corn field" (Eisenhower, 1956). The same perspective, with appropriate specifics and reinforcement of the message in relation to outsiders looking in, can be applied to the Qinghai-Tibet Plateau. There are no easy answers on the Qinghai-Tibet Plateau.

Acknowledgements

This article was presented as a peer-reviewed paper at the 21st International Farm Management Congress, Edinburgh, United Kingdom, July 2017 and is reproduced by kind permission of the International Farm Management Association.

This paper draws on information provided by pastoral farmers living on the Qinghai-Tibet Plateau. We acknowledge their willing assistance, together with the assistance and insights of other local citizens and officials who facilitated our work. Our work on the Plateau is supported by funding from the New Zealand Ministry of Business, Innovation and Employment (MBIE No. LINX1404) which facilitates our collaboration with Qinghai University, who have collaborative funding through Chinese Ministry of Science and Technology (MOST Project 2015DFG31870).

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BOOK REVIEW

DOI: 10.5836/ijam/2017-06-146

Indian agriculture: Trends in food grain production

by Trinadh Nookathoti

Published 2017 by Cambridge Scholars Publishing, Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK. (www.cambridgescholars.com). ISBN (10): 1-4438-7278-4 and ISBN (13) 978-1-4438-7278-2. £64.99. 272 pages, 69 tables and 13 figures.

Indian agriculture, just as the broader Asian agriculture, has always provided insights into the key challenges of the peasant or smallholder farming that predominates in the developing world and the policy imperatives for its transformation. Recent global initiatives, including the Millennium Development Goals and its successor Sustainable Development Goals, as well as regional and national programmes, have shed more light on why change is inevitable. The focus on poverty reduction (or its complete eradication) and food security reflects the anxiety over the myriad problems associated with conditions of extreme deprivation. Its sheer size, in both land and population, makes India an important test case for the workability or otherwise of some of the thematic issues around which global action has been deployed for some decades now.

The book has emerged from what is clearly a rigorous and systematic and evidently focused doctoral study of the trends in food grain production to help explain the causes of hunger and malnutrition in rural India and what elements allow for effective remedial actions to be taken. In seven chapters, the author has attempted to provide an exhaustive profile of Indian Agriculture and Indian society at large. Evoking the timeless insights of the legendary father of India's constitution, Dr BR Ambedkar, the author makes a case for expanding the definition of democracy to embrace improvements of individual welfare which includes having adequate food and nutrition. But even constitutional protection has not prevented India from the ignoble distinction of being the only Asian country to experience severe food shortages as far as collective memory goes.

An introductory chapter traces the definitions of food security in all its ramifications and from the perspectives of both national and international policy makers. A clear link is thus made between poverty and food insecurity with very interesting, if disturbing, statistics about current and prospective situations. The concern that recent growth rates are not making much impact on malnutrition highlights the extreme inequalities in the country but also reflects some international developments that range from changes in energy prices and patterns of international trade as well as changes in weather patterns occasioning climate change. In some way, it emerges that chronic hunger that is frequently experienced is more pernicious than the worst natural disasters, of which there are also many. The chapter provides several examples of the role of international commitments and how historical facts such as the Green Revolution and national policies that came before and after defined the path taken by Indian agriculture. All these lead to the identification of a research gap, specification of research objectives and methodology, data sources and analytical procedures that students and policy makers will definitely find very helpful.

Chapter 2 is devoted to an elaboration of the conceptual framework for examining the country's food insecurity. The diverse and multiple elements that are implicated in food insecurity are explored by means of a very comprehensive literature review and document analysis, drawing from the time-tested insights of such notable authorities as Amartya Sen, Jean Drez, MS Swaminathan, among others. A concept of food security that considers food availability, household entitlement, stability of food supply year-round and protection against malnutrition, is proposed. Everything considered, a compelling case is made that expansion in grain production has not translated to improved nutrition due to structural shortcomings that have hurt the poorer segments of the population, including women.

Chapter 3 focuses on the question of agricultural growth and its implications for food security. The primal role of agriculture in Indian's development is stressed. The complex terrain of Indian agriculture is described with robust statistical details that present its major characteristics, its key outputs and how these have changed over time, its contribution to the GDP and how this has evolved, and growth rates at different epochs and what seems to have influenced them. Attention is paid to the unique cultural base of India and how this continues to show up in wider national issues and continues to influence and be influenced by the policy.

In chapter 4, the main theme of the book is examined in terms of the trends in food grain production and what it means for self-sufficiency, a goal that has pre-occupied national policy for much of the country's existence as a sovereign state. Key questions addressed are what factors are implicated in the observed trends over time and how these differ for individual commodities such as rice, wheat, pulses, etc. Again, the role of global and national, including regional, policies, are examined. The role of globalization is explicitly x-rayed in terms of the challenges it poses and the opportunities it offers to equalize access for the generality of the Indian population.

Chapter 5 introduces the quantitative techniques employed in the literature to perform projections of future demand and supply, factoring in anticipated changes in dietary patterns and other developments both within and outside India. Unless something drastic happens, there is nothing in the projections that holds out much promise that tomorrow will be better for India's agriculture within existing technological and policy configurations.

Chapter 6 presents actual data analysis and their interpretations. Using simple non-parametric statistics, the book presents average area cultivated, gross production and yield aggregated for the system as a whole and broken down by enterprise. Growth rates are also presented and gaps that need to be filled in order to make the system more supportive of the needs of the population are identified. More robust but accessible statistical procedures are also described and applied to yield insights on which policy interventions can be safely anchored.

Chapter 7 winds up with findings and suggestions that build on the notion that India's future is intimately linked with its agriculture whose prosperity sets the tone for what happens to the broader economy. Ultimately, the hard data will make the difference between practical realities of dealing decisively with the severe shortages that countries confront and whether or not they can reverse the trends from destitution for the many, to prosperity for all. This book is a first in many respects. It combines historical antecedents with contemporary conditions of food insecurity, deprivation and shortages, as well as practical steps for computing national food balance sheets using simple techniques. From that point of view, it straddles the entire knowledge value chain from the primary didactic levels where it has the potential to fill in existing gaps in essential resource books that address practical hands-on training needs of beginners, to the policy advisory and intervention levels. This makes it an indispensable companion for a wide constituency, be they beginning students, mature scholars or policy makers. Whether or not one is interested in Indian agriculture *per se* is immaterial. The concepts are without borders and are as timeless as they are topical and will remain worthwhile for sometime.

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