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# Brexit: ultimately it's trade that matters

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## 1. Introduction

Officially the NFU of England and Wales has declined to take a position ahead of the conclusion of the UK government's renegotiation on future EU membership. It argues that until the details of an agreement are revealed it is impossible to measure the impact of Brexit on British farmers (NFU, 2015). That said, it would be surprising if the majority of British farmers did not fear that their businesses would suffer if the UK voted to leave the EU. Unconstrained by the Common Agricultural Policy (CAP) a British government would be free to reduce the level of financial support for the sector and terminate agricultural exceptionalism thereby placing farming in the same position as industries in general. Before considering the implications in more detail it is worth pointing out that reports suggesting that Brexit would be devastating for UK agriculture (see for example Agra Europe, 2015) fail to fully allow for the fact that the impact of lower financial support on production would be mitigated by a reduction in the industry's cost base and restructuring towards more productive, larger scale farms.

As the government has not made any pronouncements regarding agricultural policy if freed from the CAP we must rely on previous governments' submissions for guidance. In 2005 the Labour government published its 'vision for the CAP' (Treasury, 2005) and in advance of the 2013 CAP reform the Coalition set out its objectives (Defra, 2011). Both publications argued for the phasing out of decoupled payments – broadly the CAP's Pillar I, Basic Payments Scheme (BPS) – while continuing to finance agri-environment schemes and rural development ie, payments falling under Pillar II. As Pillar I payments amount to about three quarters of CAP expenditure and de facto, serve largely as income augmenting social payments, this appears to threaten a substantial reduction in farm incomes. In a detailed study published in the run-up to the 2013 CAP reform, the Commission argued that phasing out direct payments would lead not only to much larger and more capital intensive farms but also production systems would become more intensive in the most productive regions and land would be abandoned in less advantageous areas (Commission, 2011).

On the basis of this and other studies it might seem reasonable to expect that structural change along the lines projected by the Commission would be manifest in the UK if the level of farm support was rapidly reduced. However, there are two reasons to suspect that in the event of Brexit, the structure of UK agriculture would not vary markedly from what it would otherwise have been in the following years. Firstly, structural change involving a steady decline in the number of farm holdings has been a feature of UK agriculture since 1945. There are currently 212,000 farm holdings in the UK but some three quarters of the agricultural area is farmed by just 42,000 holdings (20 per cent) with an average size of 304 hectares. The numbers of these larger scale farms have remained relatively stable over recent years whereas the population of smaller scale holdings has declined steadily. This pattern is likely to continue whether or not the UK remains within the EU, particularly as farms with an area of less than 5 hectares in England and Wales – 3 hectares in Scotland and Northern Ireland – are not eligible for support under the BPS.

Secondly, despite the declared intention to reduce support, neither Party's submission on the future of the CAP set a time table for the removal of decoupled payments. There are good reasons to doubt that the overall reduction in public expenditure on agriculture would be as large as indicated. The pace and extent of reform, following Brexit, would be subject to negotiation not only with the devolved administrations in Scotland, Wales and Northern Ireland but also with the NFU and other lobbies. The devolved administrations are supportive of the BPS as a significant proportion of their farms would be vulnerable by virtue of their smaller scale and more difficult geography. Thus, there would be pressure to retain current levels of spending and, I suspect, pressure to limit any redistribution towards the more prescriptive Pillar II type schemes. And should English farmers be threatened with a steeper cut in decoupled payments than their counterparts in the regions the NFU would mobilise its considerable political influence. More generally the government would face the political charge that by phasing out decoupled payments it was subjecting British farmers to an 'uneven playing field' and there might be claims for compensation. That said, even with transitional arrangements spread over a period of years the likelihood is that UK decoupled payments would decline relative to EU payments in the years following exit.

Moving beyond financial support; previous UK government submissions have argued for the removal of remaining trade barriers and greater liberation for farmers in making decisions regarding their businesses. This suggests that outside the EU competitiveness would replace social welfare as the primary policy objective. But again, it is far from clear to what extent a future government would remove existing regulations. Leaving

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trade matters aside for the moment, consumer, environmental and public health organisations have considerable political influence and would argue forcibly against any moderation of existing EU Directives regarding pollution eg, nitrate and pesticide leaching, water quality, birds, habitats and animal welfare.

A more likely change would be a more positive attitude towards the frontiers of agricultural science and technology. No longer subject to the CAP's voting rules, a British government is likely to more aggressively support the adoption agro-biotechnology as a means to improving competitiveness. Further, both farmers and their suppliers would benefit from the UK's exit from the EU's long drawn out, opaque system for approving new pesticide products. There is however, a question as to how quickly British farmers would take-up the more controversial technology of genetic modification. Although a recent survey showed that only 14 per cent of UK consumers are strongly opposed to GM foods, 82 per cent remain undecided or hold only mildly positive or negative opinions (IGD, 2014).

Given a focus on international competitiveness of key importance would be the UK's post exit trade relationship with the EU. There are in principle four trade relationships that the UK could seek with the EU (House of Commons (a), 2013): a highly integrated option of a European Economic Area (EEA) agreement; a less conditional European Free Trade Area (EFTA) agreement; a UK specific preferential Regional Trade Agreement (RTA); or resort to a WTO most-favoured-nation (MFN) agreement. Unfettered access to the single market would be a priority for the food industry but this is an unlikely outcome. An EEA agreement would appear to offer the greatest likelihood of equivalence to existing arrangements. However, the House of Commons Foreign Affairs Committee inquiry into the UK's future relationship with the EU concluded… *we agree with the Government that the current arrangements for relations with the EU which are maintained by Norway, as a member of the European Economic Area, or Switzerland, would not be appropriate for the UK if it were to leave the EU* (House of Commons (b), 2013, pp9). A position reiterated by the Prime Minister in his recent speech to the Northern Future Forum in Iceland.

Presumably, the government's preferred option would be to negotiate a preferential RTA. The Out campaigners assert that a satisfactory RTA could be negotiated but they provide no articulation on the details of such an agreement. They rely on the argument that as the UK has a persistent trade deficit with the EU in food and agricultural products – £16.4bn in 2014 (Defra 2014) – it would be in the EU's interest to reach a negotiated bilateral agreement on such products. However, a key issue would be the willingness of the EU to enter into a preferential RTA if it did not include the four 'freedoms' involving the movement of goods, capital, services and people that are conditional in the EU's treaties with the EEA and EFTA. Even if the UK negotiates a way round the free movement of people it is unlikely that UK agriculture, and businesses in general, could retain all the trade freedoms eg, mutual recognition, currently enjoyed within the single market – the consequence of which would be to devalue membership of the EU for remaining members.

If a satisfactory preferential RTA proved unnegotiable the UK would have to revert to existing WTO agreements. In this situation as the prospect of a new multilateral trade agreement is now vanishingly small, UK farm and food exports to the EU would face both tariff and non-tariff barriers. To take but one of many examples of the former: exports of cheddar cheese with a minimum fat content of 50 per cent would face a tariff of €167.1 per 100kg. Non-tariff barriers would primarily be concerned with compliance eg, UK exports would be subject to the CAP's regulations concerning maximum pesticide residues. Indeed, the idea that outside the EU the government would have complete freedom of action regarding agricultural policy is a fiction; even its WTO commitments impose constraints. Given that the EU will remain an important trading partner, the UK would find it in its self-interest to align its regulations and standards closely to those in force in the EU. And in many areas of food and agricultural policy, EU standards are based on existing WTO standards eg, Codex Alimentarius. Paradoxically, the adoption of GM technology by UK farmers would not pose a problem as despite the EU's almost complete moratorium on growing GM crops the same products can be imported from non-EU countries. This still leaves the issue of the EU's existing RTAs with third countries. Presumably, the UK would seek to negotiate new RTAs with these countries in order to continue with the EU's tariff preferences. But there might be opposition; for example, Brazil might protest if the UK offered tariff concessions on raw sugar to Least Developed Countries (LDCs) as if it were still applying the EU's Economic Partnership Agreements.

## 2. End Piece

There is little prospect of the CAP's multifunctional approach to agricultural support changing significantly in the foreseeable future. This suggests that in the event of Brexit, UK agricultural policy reform is likely to move at a faster pace and also in a direction that gives primacy to productivity and competitiveness. While this consequence is to be welcomed arguably of more importance would be the extent of the food and agricultural industries' access to the single market. Despite the claims of Eurosceptics it is impossible at this time to anticipate how successful the UK might be in this endeavour or how long negotiations would last. The inevitable uncertainty could result in longer term adverse consequences; such as, some multinational food companies relocating to other parts of the EU. Finally, those hoping for a rapid reduction in wasteful public expenditure on agriculture are likely to be disappointed as powerful lobbies would bring their influence to bear to minimise the cuts and to prolong the transitional period.

## About the author

**Sean Rickard** PhD, MBA, MSc, BSc, FHEA, RiVF, was for 10 years Chief Economist for the National Farmers' Union before joining the Cranfield School of Management in 1995 where inter alia he was Director of the MBA Programme. After leaving the NFU he was for 17 years appointed as a government academic economic advisor on food and farming matters. Since retiring from Cranfield in 2012 he has established a consultancy specialising in these areas and is a visiting research fellow at the Royal Institution. His book, The Economics of Organisations and Strategy is published by McGraw-Hill.

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# Understanding work organisation factors on thoroughbred farms in southeastern United States

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**ABSTRACT**

There is little reported on the work environment of thoroughbred breeding operations. As a first step toward minimizing risk in this hazardous industry, this study documents farm and workforce characteristics, employment conditions, and organisational and job factors on thoroughbred farms in one southeastern state in the U.S. Data were collected via a phone-administered survey with a convenience sample of management representatives (owner, manager, or human resource personnel) from 32 thoroughbred breeding farms. Farms chiefly employed a full-time, non-native, low-wage labour force that worked long hours year-round, but that was offered numerous benefits. Seasonal workers, also commonly employed, received low wages, few benefits, and experienced low retention. Future research is necessary to determine how the interplay between work organisation factors influences farmworkers' risk of injury and illness as well as their subsequent health outcomes.

**KEYWORDS:** Occupational safety and health; work organisation; animal handling; farmworkers

## 1. Introduction

A worker's experience on the job is a result of several interwoven factors involving both the individual and the work environment (Sauter, et al., 2002; Landsbergis, Grzywacz, & LaMontagne, 2014). Some of the more proximate factors influencing worker health are the direct hazards and tasks to which a worker is exposed on a daily basis. More distal factors include how jobs and organisations are designed, structured, and managed. Taken together, these myriad influences comprise the concept of work organisation (See Figure 1).

Previous research has demonstrated that work organisation factors at all levels may influence worker health (Vandenberg, et al., 2002), with job-specific factors mediating the effects of organisational factors on health outcomes (Landsbergis et al., 2014; MacDonald et al., 2008). However, research looking specifically at the interface of work organisation and occupational safety and health in physically demanding industries such as agriculture is sparse (Grzywacz et al., 2007a; Grzywacz et al., 2013; Marín et al., 2009; Swanberg et al., 2012; Swanberg et al., 2013a). This is a serious omission given the high risk nature of many agricultural jobs and agriculture's increasing dependence on foreign-born, non-English speaking workers (Arcury & Quandt, 2009; Carroll et al., 2005), who, because of language barriers, cultural differences, and heightened stressors outside of work, are more vulnerable to risk and injury (Luchok & Rosenberg, 1997; Grzywacz, et al., 2007b; Marin, et al., 2009; NORA AgFF Sector Council, 2008).

The influence and nature of employment conditions in agriculture needs to be assessed because agriculture is exempt from many regulations that mandate worker protection policies, such as minimum wage, overtime payment (USDoL, 2014), and—in many states—workers' compensation insurance (Runyan, 2000; Utterbach & Schnorr, 2010). Because agricultural work is frequently characterized by long hours and hazardous conditions (May, 2009), and the agricultural labour force is further comprised of a vulnerable labour force (Arcury & Quandt, 2009; Carroll et al., 2005), an understanding of the interaction of these policies and practices on worker health is vital to reducing injuries (MacDonald et al, 2008). Further, agriculture is a diverse industry and in order to understand how organisational and job factors may contribute to its high injury and illness rate, these factors must first be documented (Grzywacz et al, 2013).

One sector within agriculture about which very little is known is work on horse breeding farms, specifically thoroughbred breeding operations (Swanberg et al., 2013b). As part of animal agriculture—the sector of

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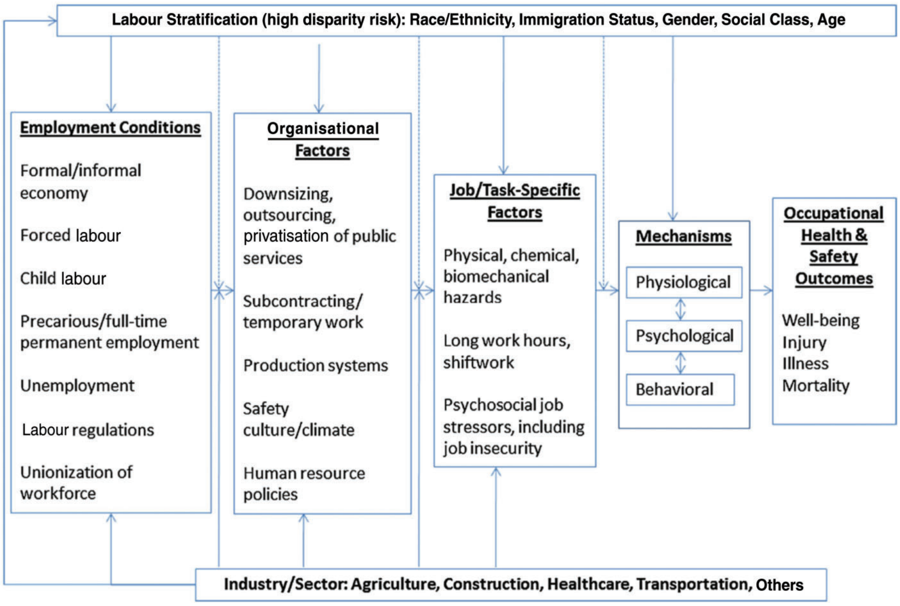


**Figure 1:** Conceptual overview of role of work organization in occupational health disparities (Landsbergis et al., 2014)

agriculture with the highest rate of nonfatal injury and illness (BLS, 2013b)—thoroughbred breeding consists of the care and procreation of a stud and a mare and the delivery and early development of the foal. Unlike most livestock, thoroughbreds are bred and trained for racing; thus, for their agility, speed, litheness, and power. They typically weigh around 1,000 pounds, stand 16.1 hands tall (64.4 inches), and can travel at speeds of 40 miles per hour (The Jockey Club, 2006). Breeding and tending thoroughbreds can put workers at risk of severe injury due to the horse's strength and unpredictable nature (Swanberg et al., 2013b).

Existing research reveals that thoroughbred farmworkers face the risk of kicks, bites, falls, tramplings (Iba, 2001; Swanberg et al., 2013b) and injuries to the extremities, head and chest (Swanberg et al., 2013b). Research on equine workers in the US and Europe suggests workers also face threats of exposure to respiratory irritants (CDC, 2009; Elfman, et al, 2009; Kimbell-Dunn, et al., 1999; Kimbell-Dunn, et al., 2001; Samadi et al., 2009; Mazan et al., 2009; Swanberg et al., 2012), high postural loads when bending or twisting (CDC, 2009; Löfqvist & Pinzke, 2011; Löfqvist et al., 2009), toxic chemicals/medicines (Swanberg et al., 2012), and fatalities (Langley & Hunter, 2001; CDC, 2009).

Very limited research on the occupational health and safety of thoroughbred farmworkers has described the employment conditions and organisational factors common on horse breeding farms (Clouser, Swanberg, & Bundy, 2015; Swanberg et al., 2013a). Such factors have the potential to reduce exposure to hazards and subsequent health disparities (Landsbergis et al., 2014; Lipscomb et al., 2006). In addition, workplace-focused interventions targeting both work organisation and working conditions may not only improve worker health outcomes, but also working conditions (Landsbergis et al., 2014). A first step in the reduction of injury and fatality rates of thoroughbred horse workers requires a better understanding of employment conditions (e.g., full-time/part-time work, labour practices/regulations) organisational factors (e.g., human resource policies), job factors (e.g., job type/tasks), and demographic characteristics of thoroughbred farms (Swaen et al., 2004; MacDonald et al., 2008; Sauter et al., 2002; Landsbergis et al., 2014; Grzywacz et al., 2013). While it is undoubtedly important to gather workers' experiences of how their work is organised, it is possible that workers may not fully understand the benefits and practices that are available to them (USDoL, 2005). Thus, in order to determine optimal avenues for workplace-based intervention, it is also important to understand work organisation factors as intended by the employer (farms).

This analysis is part of a larger study that aimed to systematically document the demographics, work organisation factors, and occupational health of farmworkers employed on thoroughbred farms from both the employer and worker perspectives and to develop intervention materials to promote the safety and health of these workers. The present analysis reports on data gathered from farm representatives and details the farm and workforce characteristics, employment conditions, and organisational and job factors of thoroughbred horse farms.

## 2. Methods

The study methodology, more fully described elsewhere (Clouser et al., 2015; Swanberg et al., 2013b), used data from a telephone survey conducted with representatives from thoroughbred farms (employers) in one southeastern state[3]. The study was guided by two advisory councils; one representing the thoroughbred industry and another representing workers.

### Eligibility, sampling, and recruitment

A sampling frame of 82 thoroughbred breeding farms was developed by the industry advisory council to approximate the farm size distribution in the region: 70% employ ten or fewer workers (small), 15% employ 11-25 workers (medium), and 11% employ more than 25

[3] To protect the anonymity and confidentiality of the employers participating in this study, specific location is not disclosed.

workers (large) (Nutt, et al, 2011). Because no known database reports horse farm size by number of employees, size was estimated by advisory council members and was confirmed or corrected in the interview. A convenience sample was used instead of a stratified random sampling strategy due to 1) the intensive nature of the study and the targeting of owners/managers for whom time is limited[4], 2) the sensitive nature of the study's scope (questions specific to farms' vulnerable workers were included in the full protocol), and 3) the proprietary and close-knit nature of the industry, whereby entry onto a farm may require an introduction to gain trust of participants.

Eligible farms 1) were engaged in thoroughbred breeding and/or boarding[5] as their primary function; 2) employed at least one Latino farmworker; and 3) were located in one southeastern state in the U.S. A farm representative was eligible if he/she was 18 years or older and responsible for human resource, supervisory and/or workplace safety functions. Farm representatives may have been the farm owner, farm manager or another administrative personnel (human resource manager, office manager) depending on the organisational structure of the farm. If, through the course of the interview, another employee was better equipped to answer certain questions, that second employee was enrolled in the study and asked the relevant questions.

Sixty-two farms met eligibility criteria, of whom 32 completed the phone interview (52%). A letter prepared and signed by two members of the industry advisory council and the Principal Investigator (PI) was sent to the farm contact describing the study's goals and methods. Within seven days, a trained interviewer called the farm. If eligibility and consent were affirmed, the farm was enrolled in the study. Research procedures were approved by the research institution's Institutional Review Board. Data were collected between October 2012 and March 2013.

### Study procedures

The telephone interview included 73 questions about farm and workforce characteristics, employment conditions, and organisational factors. Most questions were from industry or compensation questions common on employer and/or agriculture farm surveys [i.e., National Agricultural Workers Survey (USDoL, 2005); Health and Safety of Virginia Agriculturists Study (Virginia Technical College, 2006); Kentucky Equine Survey (Kentucky Horse Council, 1978)] and modified as necessary. Other items were investigator generated and the instrument was pilot tested before data were collected.

### Measures

Information collected on *farm characteristics* included farm size, type of thoroughbred operation, and other farm commodities, and seasonality of business operations. *Workforce characteristics* gathered about farmworkers included information on gender, race, ethnicity, nativity, and native language. Respondents were asked to provide the percentage of farmworkers in each category. Due to the aggregate nature of this reporting, data on age were not gathered about the workforce. When administrative/employment data could be referenced, this was used; if not, an estimate was provided. The workforce was divided into two worker groups: year-round and seasonal workers. Year-round workers were defined as regular employees that worked on the farm throughout the previous year. Seasonal workers were those hired for discrete periods of the same previous year.

*Employment conditions* included information about the workforce including: number of farmworkers employed full-time and part-time based on farms' definitions of each; presence of contract workers that worked directly on the farm compared to those that worked at sales or offsite; and provision of workers' compensation insurance (See Figure 2).

*Organisational factors* included human resource policy and practice information on average hourly wage among full-time, part-time, and seasonal workers. Three categories of *employee benefits* were assessed: health insurance, paid leave, and other benefits. Provision of *health, dental, and/or insurance* by farms was measured with yes/no variables. Three forms of *paid leave* were assessed: paid vacation days, paid sick days, and general paid time off. General paid time off is a generic form of leave that workers can use as needed, though its provision was not necessarily mutually exclusive from vacation or sick leave. Each form of leave was further categorized into "formal," in which a designated number of days was provided per year, or "informal," in which leave was granted on a case-by-case basis or with no specific allotment of days. Composite variables for "any formal paid leave" and "any informal paid leave" were created by combining the three forms of leave for each category. Provision of *other employee benefits* was also measured using an open-ended question, which was then coded as "yes" if any were offered and "no" if not.

Data on the provision, language, and distribution practices of employee policy manuals and employee safety manuals was collected. Manual content was not analysed in this analysis. Finally, *job factors* included information on hours worked (e.g., farms' definitions of full and part-time status), annual retention rates, and common job classifications.

### Analysis

Phone survey data were entered into SAS (SAS Institute, 2011) for analysis. Univariate descriptive statistics were performed to describe basic farm demographics, estimated worker demographics, organisational and job characteristics, and safety practices as reported by the farm representative. Due to wide ranges reported, the median and interquartile range (IQR) are generally reported.

## 3. Results

### Farm characteristics

Farm characteristics are reported in Table 1. A plurality of farms in the sample reported having ten or fewer workers. Farms had a median workforce of 12 workers, with a range from 1-230. Over a third of farms also raised crops or livestock. All farms reported having at least one and often multiple busy seasons. The busiest months reported were (in descending order) May, April, March, and February, corresponding to the breeding and foaling season.

[4] Although this paper focuses only on a telephone-administered survey, other data were collected via a 1-4 hour face-to-face interview and farm walk-through conducted with 26 of the 32 participating farms.

[5] Breeding farms kept their own mares or stallions for breeding purposes whereas boarding farms collected boarding fees from clients for horses kept on the property. Farms may have been involved in both activities.


**Figure 2:** Work organisation constructs included in the analysis (Based on Landsbergis, et al., 2014)

## Workforce characteristics

The demographics of the year-round and seasonal thoroughbred farmworkers are reported in Table 2. The estimated majority of year-round farmworkers, as reported by farm management, were male, Latino, and foreign-born. However, farm representatives estimated that about a third of their workforce was non-Latino White. Foreign-born workers representing 27 different countries were reported, with the large majority originating from Mexico.

The majority of seasonal farmworkers were male and foreign born; half were identified as non-Latino White and half as Latino. All farms with foreign-born workers reported having Spanish-speaking workers. Moreover, among farms with non-native seasonal workers, nine out of ten reported having workers from Mexico.

## Organisation of work on thoroughbred farms

### Employment conditions

Employment conditions are reported in Table 3. Farms reported that the majority of year-round farmworkers were employed full-time, though one-third of farms also hired part-time workers. More prevalent than part-time workers were seasonal and contract workers, with two-thirds and three-fourths of all farms hiring them respectively. Farms hired a median of four seasonal workers in the past year (range 1-235), working from 2 to 11 months. Only two farms used the H2-A program, the temporary visa program for agriculture. Ninety-four percent of farms had workers' compensation insurance.

### Human resource policies and practices

Employee compensation and benefits are reported in Table 4. Farms reported paying full-time farmworkers a median hourly wage of \$9.50[6], with a range of \$7.50 to \$13.50[7]. Part-time and seasonal farmworkers earned less per hour: \$8.80[8] (Range: \$6.20-\$20.00[9]) and \$8.60[10] (Range: \$7.30-\$11.50[11]) respectively.

Overall, half of the farms reported offering individual health insurance to their full-time year round farmworkers. Of those that did, just under half paid the complete premium, while the rest paid a partial premium. Among the 47% of farms that extended coverage to frontline workers' families, a third paid the full premium, a third paid a partial premium, and a third did not contribute to family coverage. Individual or family health insurance was not offered to part-time workers or their family members yet one farm offered both types of health insurance to seasonal workers. Approximately one quarter of all farms reported offering full-time workers' retirement plans, dental insurance, and life insurance.

Overall, the vast majority of farms reported offering farmworkers some form of formal or informal paid leave to full-time workers and very few offered paid leave to either part-time or seasonal workers (See Table 4).

A majority of farms reported offering full-time workers paid vacation days (84%) and had a formal (81%) vacation policy offering a set number of days off each year. Among those with a formal vacation policy, the mean number of days for full-time year-round workers was 8.6 (Range 5-14). No paid vacation was provided to part-time or seasonal workers.

Most farms reported offering full-time workers paid sick leave (81%) and nearly half (47%) had a formal paid sick leave policy. Among those with a formal policy, the mean number of days provided to full-time year-round workers was 4.9 (Range 3-7). No farms provided sick leave to part-time or seasonal workers.

A quarter of farms reported offering "general paid time off" that could be used at the worker's discretion for sick or personal time. The mean number of days off provided to full-time workers was 6.8 (Range 2-16). The one farm that provided general paid time off to seasonal workers provided 6 days.

Housing and bonuses were provided by over a third of farms, while almost a third provided retirement. Many other benefits were also provided by farms in our sample (See Table 4).

Less than half the farms (41%) reported providing workers with an employee policy manual, and very few translated it into Spanish. Safety manuals were much less prevalent, and only one farm translated one into Spanish.

### Job factors

Job factors are reported in Table 5. Most farms self-defined full time as 48 hours per week (generally 8 hours per day, 6 days a week). However, some outliers reported full-time as ranging from 22.5 hours to 54 hours per week. Farms reported that they retained the majority of their full-time workforce, with 88% of farmworkers having also worked the previous year. Though farms differed in how part-time was defined (ranging from

[6] At the time of writing (July, 2015), \$9.50 was approximately equivalent to £6.09 and €8.73.
[7] At the time of writing (July, 2015), \$7.50-\$13.50 was approximately equivalent to £4.80-£8.66 and €6.89-€12.40.
[8] At the time of writing (July, 2015), \$8.80 was approximately equivalent to £5.64 and €8.08.
[9] At the time of writing (July, 2015), \$6.20-\$20.00 was approximately equivalent to £3.98-£12.82 and €5.70-€18.37.
[10] At the time of writing (July, 2015), \$8.60 was approximately equivalent to £5.51 and €7.90.
[11] At the time of writing (July, 2015), \$7.30-\$11.50 was approximately equivalent to £4.68-£7.37 and €6.71-€10.56.

**Table 1:** Farm Characteristics (N=32)

| Farm size | Median | IQR[1] | Range |
|---|---|---|---|
| Acres devoted to thoroughbred operation | 369.5 | 637.5 | 30-6000 |
| No. of thoroughbreds | 100 | 140 | 6-516 |
| No. of all workers on farm[2] | 12 | 23 | 1-230 |
| **Farm size by number of year-round employees** | **N** | **%** | |
| Small (⩽10 workers) | 14 | 43.8 | |
| Medium (11-25 workers) | 9 | 28.1 | |
| Large (>25 workers) | 9 | 28.1 | |
| **Thoroughbred operation includes** | **N** | **%** | |
| Sales | 32 | 100 | |
| Breeding | 30 | 93.8 | |
| Boarding | 26 | 81.3 | |
| Racing | 26 | 81.3 | |
| **Other farm operations** | **N** | **%** | |
| Additional commodities | 12 | 37.5 | |
| Crops | 8 | 25 | |
| Livestock | 8 | 25 | |
| Livestock and Crops | 4 | 12.5 | |

[1] IQR stands for Interquartile Range.
[2] Includes both office personnel and farmworkers employed in 2012.

15-45 hours per week), retention of part-time workers was 100%. Retention of seasonal workers was much lower, with only half of seasonal workers (49%) having also worked at the farm the previous year.

Five major job classifications were prevalent on the thoroughbred farms. Grooms, who chiefly fed, bathed, walked, and cleaned up after horses were employed at every farm. Two-thirds of farms hired maintenance workers to operate machinery or repair equipment and structures. Night watch workers (who oversaw horses at night) were also common, especially during foaling season. Other prevalent positions included grounds/landscaping workers and exercise riders who rode horses to prepare them for competition. Over two-thirds of farms indicated that workers performed multiple job functions.

## 4. Discussion

This is the first known study of the farm and workforce characteristics and work organisation factors of thoroughbred farms. Authors agree with other researchers (Grzywacz et al., 2013) that to improve the quality of agricultural jobs and reduce injuries and illness among workers, knowledge about work organisation is required. To this end, our study yields three main findings.

First, while horse breeding shares commonalities with other areas of agriculture, it is unique in several ways. Year-round farmworkers in our sample are comparable demographically to national estimates for crop workers; that is, the majority were foreign-born, male, and Latino (NCFH, 2012; Carroll, Georges, & Saltz, 2011; Gouveia, 2005; USDoL, 2005). However, a third of year-round and half of seasonal workers as reported by farm representatives were non-Latino White. Future research on seasonal workers should gather information from both non-Latino and Latino workers to explore whether the two worker groups experience the same exposures and health outcomes.

Thoroughbred farms in our sample rely on a steady, full-time, year-round workforce that is augmented—rather than dominated—by seasonal, and/or contract

**Table 2:** Estimated Characteristics of Year-Round and Seasonal Farmworkers

| | Year-Round Workers[1] (N=32) | | Seasonal Workers (N=20) | |
|---|---|---|---|---|
| **% of workers on farms:** | **Median** | **IQR** | **Median** | **IQR** |
| Male | 95.0 | 12.5 | 95.0 | 24.5 |
| White (non-Latino) | 29.5 | 48.0 | 50.0 | 92.5 |
| Black (non-Latino) | 0.0 | 0.03 | 0.0 | 0.0 |
| Latino | 69.0 | 46.8 | 50.0 | 85.0 |
| Foreign-born | 70.0 | 45.0 | 50.0[1] | 95.0 |
| Native language not English | 58.0 | 49.5 | 50.0[1] | 95.0 |
| **Farms with foreign-born workers from…** | **N (N=26)** | **%** | **N (N=12)[2]** | **%** |
| Mexico | 25 | 96.2 | 11 | 91.7 |
| Ireland | 5 | 19.2 | 2 | 16.7 |
| Guatemala | 3 | 11.5 | 2 | 16.7 |
| Brazil | 3 | 11.5 | 0 | 0 |
| Other[3] | 3 | 11.5 | 5 | 41.7 |

[1] Workers hailed from 23 other countries.
[2] Includes full-time and part-time front-line farmworkers.
[3] Data missing from 1 farm.

**Table 3:** Employment Conditions[1] (N=32)

| **Year-round workers** | **Median** | **IQR** | **Range** |
|---|---|---|---|
| No. year-round farmworkers | 9.5 | 15 | 1-180.0 |
| **Other non year-round farmworkers** | **N** | **%** | |
| No. farms with part-time workers[2] | 11 | 34.4 | |
| No. farms with seasonal workers | 20 | 62.5 | |
| No. farms with contract workers[3] | 24 | 75.0 | |
| **No. other workers** | **Median** | **IQR** | **Range** |
| No. of part-time workers per farm (N=11) | 1.0 | 1.0 | 1.0-12.0 |
| No. of seasonal workers per farm (N=19) | 4.0 | 6.0 | 1.0-235.0 |
| **Workers' compensation** | **N** | **%** | |
| Farm has worker's compensation insurance | 30 | 93.8 | |

[1] All statistics in the table refer to farmworkers, or workers not in office or management positions.
[2] Part-time status was defined by farms based on number of hours per week worked, which are reported in Table 5.
[3] Workers that were not hired as regular farm staff, but on a contract basis for work conducted on the farm. Detailed information about the number of contract workers hired/farm per farm and average hourly rage were difficult to obtain as farm representative did not always know how many contract workers they employed.

help. Qualitative data that were gathered as part of this project reveals that farms' hiring practices for seasonal workers vary (Swanberg, unpublished data). For example, some farms hire seasonal workers to show horses at sales, whereas others will simply divert their standard workforce to this purpose. On other farms, seasonal work chiefly comprised of managing hay or performing landscaping work, which was reported as more often being comprised of non-Latino, native-born workers.

How this compares to other horse breeding farms in the nation is difficult due to the differing definitions used to distinguish between seasonal workers in our sample versus those used by the National Agricultural Statistics Service (NASS) (USDA, 2012)[12]. Non-NASS surveys demonstrate that the reliance on a chiefly full-time, year-round labour force is typical (Nutt et al., 2011). Despite the general reliance on a steady, regular labour force, the hours required of workers remained long. Across most of the farms, the standard workweek spans 6 days and 48 hours, which is longer than the average of 42 hours per week cited by a national sample of farmworkers (USDoL, 2005) as well as averages for hired workers cited by the USDA (USDA, 2012). Although long hours are typical in agriculture, most crop work is seasonal in nature, and therefore its demanding schedule is not sustained throughout the entire year. Given the generally physically demanding nature of horse work (Swanberg et al, 2012; Swanberg, et al., 2013b), and the exemption of agriculture from maximum work hour protections offered through the Fair Labor Standards Act (Runyan, 2000), these workers may be vulnerable to musculoskeletal disorders (Dembe et al., 2005), fatigue, poor mental health, sleep deprivation, poor recovery time, work-related injury/illness, and other health risks associated with long work hours (Burke & Fiksenbaum, 2008; Burke, 2008).

Our second finding pertains to how the compensation and benefits of thoroughbred farmworkers differ from other agricultural and low-wage workers. Farms in this study paid farmworkers average hourly wages lower than national estimates for livestock or any agricultural worker (USDA, 2012; BLS, 2013a)

Although paying lower wages, farms commonly offered benefits to full-time workers with over half offering health insurance and nearly all offering some form of paid leave and workers' compensation, despite the lack of regulations mandating these practices[13]. For context, 23% of a national sample of farmworkers had health insurance (USDoL, 2005), 48% knew they would be covered by workers' compensation (USDoL, 2005) and 20% of agricultural workers nationally had access to paid leave (IWPR, 2014). Although the number of farms that offer these benefits does not necessarily equate to the percentage of workers with access, comparison data from the employer perspective is difficult to find, especially for agriculture.

Although farms frequently offered benefits—such as health insurance and paid time off— to year round full-time workers, they rarely offered them to part-time and seasonal workers, which is consistent with an industry survey conducted in one southern state (DDAF, 2014). While the lack of these supports for such workers is not unique to thoroughbred farms, or even agriculture (BLS, 2013c; IWPR, 2014), it reveals another reason why part-time or seasonal workers—who are a needed labour force for hazardous industries such as agriculture—remain vulnerable if sick or injured (Grzywacz et al., 2013; Landsbergis et al., 2014). Further, seasonal workers' positions were precarious, with farms reporting that half of seasonal workers were retained compared to 65% of a national sample of crop workers (USDoL, 2005). As such, seasonal workers may be at an increased risk of work-related injury or illness due to their lack of familiarity with farm procedures or handling horses. Moreover, only two farms hired H2-A workers compared to half of a sample of southeastern farmworkers that were H2-A workers (Arcury & Quandt, 2009). The H2-A program mandates protections such as transportation, housing, and job security (Grzywacz et al., 2013). Minimal use of this federal program by participants may indicate underutilization within the industry, which could leave seasonal workers vulnerable.

A note of concern in workers' access to benefits is the dearth of employee policy manuals: a vehicle through

[12] The present study defined year-round workers as those working with the farm throughout the entire year. NASS defines "full-time" workers as those working 150 days or more.

[13] Data were gathered before the employer mandate portion of the Affordable Care Act went into effect, although a great proportion of farms in this sample would be exempt due to their small size. Further, the state in which data were gathered offers an agricultural exemption for workers' compensation (Runyan, 2000).

**Table 4:** Organisational Factors: Human Resource Policies and Practices

| | Full-time (N=32) | Part-time (N=11) | Seasonal (N=20) |
|---|---|---|---|
| **Hourly wage** | **Median(IQR)** | **Median(IQR)** | **Median(IQR)** |
| Average hourly wage | 9.5(1.9) | 8.8(1.5) | 8.6(1.0) |
| **Insurance** | **N(%)** | **N(%)** | **N(%)** |
| Personal/Individual health insurance | 17(53) | 0(0) | 1(5) |
| Health insurance for family | 15(47) | 0(0) | 1(5) |
| Dental insurance | 7(22) | 0(0) | 0(0) |
| Life insurance | 7(22) | 0(0) | 0(0) |
| **Paid leave** | **N(%)** | **N(%)** | **N(%)** |
| Paid Vacation Days | 27(84) | 0(0) | 0(0) |
| Formal vacation days | 26(81) | 0(0) | 0(0) |
| Informal paid vacation days | 1(3) | 0(0) | 0(0) |
| Paid Sick Days | 26(81) | 1(9) | 2(10) |
| Formal paid sick days | 15(47) | 0(0) | 1(5) |
| Informal paid sick days | 11(34) | 1(9) | 1(5) |
| General Paid Time Off | 8(25) | 0(0) | 1(5) |
| Formal general paid time off | 6(19) | 0(0) | 1(5) |
| Informal general paid time off | 2(6) | 0(0) | 0(0) |
| Any formal paid leave | 28(97) | 0(0) | 1(5) |
| Any formal/informal paid leave[1] | 31(97) | 1(9) | 2(10) |
| **Other employee benefits** | **N(%)** | | |
| Bonus | 12(38) | | |
| Housing | 12(38) | | |
| Retirement | 9(28) | | |
| Flex time | 3(9) | | |
| Short-term disability | 2(6) | | |
| Long-term disability | 2(6) | | |
| Other benefits[2] | 9(28) | | |
| **Employee manuals (N=32)** | **N(%)** | | |
| Has employee policy manual in English | 13(40.6) | | |
| In Spanish | 9(28.1) | | |
| Farm distributes when hired | 8(25) | | |
| Farm distributes when hired & annually | 1(3.1) | | |
| Farm distributes when hired & updated | 3(9.4) | | |
| Farm distributes when updated & annually | 1(3.1) | | |
| Has employee safety manual in English | 3(9.4) | | |
| In Spanish | 1(3.1) | | |
| Farm distributes when hired[3] | 1(3.1) | | |
| Farm distributes when hired & annually | 0(0) | | |
| Farm distributes when hired & updated | 1(3.1) | | |
| Farm distributes when updated & annually | 0(0) | | |

[1] Includes access to paid vacation, sick leave, or paid time off.
[2] Includes food, loans, onsite flu shots, etc.
[3] Missing data from 1 farm.

which employees learn about benefit entitlements. Such manuals were rare, and manuals in Spanish even more so. Though it may be expected that smaller farms, which were plentiful in our sample would not have such formal structures in place, the fact that manuals were so uncommon reveals that policies may be shaped and reshaped by revolving managers and/or communicated chiefly through word of mouth (Carpenter et al., 2002). This is problematic given that 91% of farms had Spanish-speaking workers. Consequently, the degree to which workers understood their access to benefits is unclear.

Our third finding refers to the variations in job factors among farms in our sample, particularly regarding work-time. There was little agreement on definitions of full- or part-time work or tenure of seasonal workers. This may not be surprising, as agricultural work is exempt from regulations such as overtime pay and minimum wage provisions (USDoL, 2014) that standardise practices in other industries. As such, farms can set their own policies about what constitutes full-time and part-time work, which vary widely. Other agricultural surveys do not distinguish between workers fully supported throughout the year by their job (defined here as year-round) and workers who were simply employed 150 days or more (USDA, 2012). This lack of standardization may promote inequality in access to employee benefits when benefits are dispersed according to job status or working time.

A final reason why policies vary so drastically across farms may be due to the prevalence of informal farm practices, such as the prevalence of informal paid leave. While this practice may increase the number of days a worker may take (as no set ceiling is defined), it is also possible that workers may not feel fully entitled to these days because special permission is required and therefore dependent on the workplace culture created by the farm manager/owner (Behson, 2005). Deciphering the differences in workers' functional access to formal versus

 

**Table 5:** Job Factors on thoroughbred farms

| **Hours worked** | **Median** | **IQR** | **Range** |
|---|---|---|---|
| No. hours considered full-time (N=32) | 48.0 | 0.5 | 22.5-54.0 |
| No. hours considered part- time (N=10) | 21.5 | 7.5 | 15.0-45.0 |
| **Annual Retention Rate** | **Median** | **IQR** | **Range** |
| Full-time Annual Retention Rate (N=32) | 87.9 | 26.8 | 0-100.0 |
| Part-time Annual Retention Rate (N=11) | 100 | 16.7 | 0-100.0 |
| Seasonal Annual Retention Rate (N=19) | 48.6 | 72 | 0-100 |
| **Job Classifications** | **N** | **%** | |
| Grooms | 32 | 100 | |
| Maintenance workers | 20 | 62.5 | |
| Night watch | 19 | 59.4 | |
| Landscape workers (ground workers) | 14 | 43.8 | |
| Exercise riders | 13 | 40.6 | |
| Workers multitask across job classifications | 22 | 68.8 | |

informal benefits is not possible with the present data; therefore, future research should probe workers about their understanding of benefits.

### Strengths and limitations

This study collected organisational data about an understudied hard-to-reach population: thoroughbred farmworkers. Further, it has done so by engaging an employer population that can provide information about the practices to which workers are exposed. It also has the advantage of including small farms in its scope, information about which is particularly hard to find due to the exemption of small farms from many regulations and/or reporting requirements (Utterback & Schnorr, 2010; USDoL, 2015).

Like all research, this study has limitations to consider when interpreting its results. Data were gathered from a convenience sampling frame of thoroughbred farms that were identified by an industry advisory council, and therefore, may not be representative of all thoroughbred farms in the region or nation. It is possible that participating farms are systematically different than those that did not participate, or were not invited (selection bias). In addition, the small sample size limits our interpretations. Nonetheless, the response rate (52%) was very high for employer surveys conducted within this industry (Nutt et al., 2011), which is a strength of our participatory approach.

Next, responses are self-reported, and therefore subject to the associated biases (e.g, recall, social desirability). However, we believe the effect is minimal. For small farms, with few employees and a highly involved owner/manager, he/she is more likely to have this information easily accessible. For larger farms, employment records were accessed to ensure accuracy.

A third limitation of our study is that our reporting of organisational factors is based on the responses of farm representatives rather than a review of their organisational records. Thus, we do not know the percentage of workers that enroll in the benefits offered by farms, or who are aware of them. We urge readers to use caution when reviewing our study's results. Future research is necessary to assess the perceptions of workers regarding access to and enrollment in benefits.[14]

Finally, it was not in the scope of this project to obtain detailed information about the experiences of contract workers on farms, although three-quarters of farms in our sample hired them. This is drastically more than the 12% of farms nationwide that were estimated to use contract workers in 1997 (Runyan, 2000). Future research should explore the specific experiences of these workers.

Despite its limitations, this is one of the first studies to gather information from thoroughbred farm representatives about work organisation factors. This information is novel and provides insight into the nature of work on thoroughbred farms and as such it is the first step in identifying the foundational work organisation factors for improving the safety and health of a diverse worker population.

## 5. Conclusion

Information on the relationship between work organisation factors and occupational health is still under investigation in many industries. Results from this employer-engaged study provide baseline information regarding workforce characteristics and work organisation factors that may influence worker health on thoroughbred breeding farms. Farms seem to rely chiefly on a full-time, non-native, low-wage labour force that works long hours year-round, but that is offered numerous benefits uncommon in agriculture. However, seasonal workers, who were also common, received low wages, few benefits, and experienced low retention. Future research is necessary to determine how the interplay between these factors influences the risk of injury and illness.

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# Evaluating the feasibility of beginning a cow/calf operation

DAMONA DOYE[1,2], ROGER SAHS[1] and SETH MENEFEE[1]

**ABSTRACT**

An aging farm population, increasing demand for beef and lessening drought conditions suggest opportunities for new beef producers. However, high cow prices and land values may create barriers to entry. This paper evaluates leasing and purchasing options for both land and cows. Investment and operating cost assumptions are explained along with loan alternatives for beginning operators. Whole farm financial statements are generated and resulting net cash flow, line of credit and total debt levels are projected for five years. Leasing cows and land is found to be a viable means of entry. Only with outside income can cows be purchased; significant levels of outside income are needed to purchase land.

**KEYWORDS:** cow/calf; beginning; rancher; feasibility; cash flow

## 1. Introduction

For individuals interested in beginning beef cattle production in the U.S., now would seem to be an opportune time. An aging farmer population suggests that a new younger cohort of producers may be needed to take over farm/ranch operations. The cowherd remains near record low numbers at a time when more beef is needed to meet market demands. And multi-year drought conditions are easing in much of the country.

The average age of farm operators in the U.S. as well as Oklahoma is 58.3 years old according to the Census of Agriculture (USDA NASS 2014, Table 1). USDA's definition of a farm is a place that normally sells or produces agricultural products valued at $1,000 or more in a year, encompassing many small and part-time operations. Further parsing of the statistics shows that of the Oklahoma producers who consider farming their primary occupation, half are over age 65 and another 25% are 55-64 years of age; thus three-quarters are at or near what might be considered retirement age. U.S. statistics are not quite as stark; 40.7 percent are over age 65 and 27.5 percent are 55-64 years old so 68 percent are retirement age.

Because the Oklahoma land base is largely pasture, beef is consistently the top ranked agricultural commodity, accounting for one-third or more of the value of production. Census of Agriculture data shows 44,000 beef cow operations, ranking third in the nation. In Oklahoma, more than half of beef producers have fewer than 50 head and more than 3/4 have fewer than 100 head (USDA NASS 2014, Table 16). Producers with fewer than 100 head account for about $\frac{1}{4}$ of the cattle inventory; 47 large producers with more than 1,000 head also account for $\frac{1}{4}$ of the cattle inventory. The average beef cow herd in Oklahoma in 2012 was 38 head; average herd size from 1987-2012 varied from 38 to 44 head (USDA NASS various issues). The average U.S. beef cow herd during that same time period varied from 40 to 43, also with the low in 2012 (USDA NASS, various issues). Data comparing the profitability of beef cow/calf operations by size is limited. The FINBIN Farm Financial Database which is populated largely by Midwest farms shows that from 2010-2014, net returns over labour and management were lowest for small operations with 50 or fewer cows and highest for operations with 201 to 500 cows (University of Minnesota 2015).

Successive years of drought in Oklahoma have shrunk the size of the cowherd at the same time that the U.S. cowherd is at a historic low in terms of numbers. With drought conditions possibly improving and markets signalling the need to rebuild the cowherd, a question arises as to the financial feasibility of adding new herds, particularly by beginning operators. But rising land values and the cost of breeding livestock make an investment in beef production costly. With high capital costs for land and livestock, gaining control of assets poses challenges for beginning producers with limited equity and experience.

Leasing land is a well-established practice as many farm operators lease some land and some lease all their land. Approximately two-thirds (67.7 percent) of farm principal operators are full owners of their farm, 25.3 percent are part-owners and 7 percent do not own land (USDA NASS 2014, Table 70). Leasing assets is often a viable alternative for a beginning producer because it requires less capital, allowing working capital to be directed to operating costs rather than debt payments, and lessens exposure to risk.

The objective of this research is to evaluate the feasibility of purchasing and leasing cows and land as alternatives for

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a beginning beef cattle producer. We summarize costs of establishing and maintaining a beef herd, identify different borrowing options, then estimate the resulting cash flow associated with different scenarios. We evaluate alternative financing arrangements for land and cattle to inform prospective industry entrants about the financial needs associated with beginning a beef operation.

## Cow/calf herd establishment costs

In this analysis, we focus on native range as a forage base. In Oklahoma, opportunities exist to purchase or rent both native range and introduced pasture. Native range is typically the most cost effective means of maintaining cattle with rents of approximately \$6 per hectare (\$15 per acre) (Doye and Sahs 2015). Native pastureland is also less expensive to buy as land on which introduced pasture is grown is often suitable for crops with higher returns per hectare than livestock enterprises. In Oklahoma, pastureland prices currently average approximately \$3,707 per hectare (\$1,500 per acre) (agecon.okstate.edu/oklandvalues).

We assume the goal is to establish a small herd of cows similar in size to the average Oklahoma herd size of 35 cows. For this analysis, each cow requires approximately 4 hectares of native pasture (10 acres) for maintenance so the required landbase is 142 hectares (350 acres). Table 1 summarizes the assets presumed to be used in the operation. Equipment includes feed bunks, loading squeeze chutes, round bale feeders and portable corral. While a small tractor is not required, and in fact, would be discouraged from a cost perspective, many small producers do choose to buy one. The investment needed to establish even a small herd of 35 cows is substantial, ranging from approximately \$60,000 to more than \$682,000 depending on whether land and cattle are purchased or leased.

Purchasing land increases the investment needed dramatically. Costs associated with controlling the land base, whether land is purchased or rented, are significant. Renting land typically presents less of a cash flow burden than buying land and is more profitable in the short run. However, land purchases can result in growth in equity if land values appreciate over time and thus be a good long term investment. Hence, we evaluate both options.

## Cow/calf operating costs

Although beef production is the most prevalent enterprise in Oklahoma, profitability is certainly not guaranteed and poses difficulties, particularly for a young producer starting with a smaller herd. Because Oklahoma does not have a database of actual ranch costs, we frequently benchmark budget data to Kansas Farm Management Association (KFMA) and Standardized Performance Analysis (SPA) data. KFMA average variable cost per cow in 2013 was \$772 per cow and the difference between the high- and low-profit category KFMA producers is approximately \$466 per cow (Figure 1). The southwest SPA summary includes some Oklahoma herds but is primarily Texas based (Bevers 2015). SPA data for 2009-13 show an average raised/purchased feed cost of \$200 per cow and grazing cost of \$107 per cow, with total financial cost of \$705 per cow. Oklahoma grazing and feed costs for native pasture based systems are expected to be more similar to Texas than Kansas.

Table 2 shows the operating cost assumptions used in this analysis. The numbers are generated by Oklahoma State University (OSU) 2014 enterprise budget software (agecon.okstate.edu/budgets). This budget includes only 30 days of hay fed so projected operating expenses presume managers appropriately stock cattle to minimize purchased feed and hay. In addition, no cash labour costs are included as it is assumed labour, an estimated 6.9 hours per cow per year, will be provided by the farm family. We presume the beginning operator will be an efficient, low cost producer.

## Whole farm financial plans

Whole farm financial plans to compare the alternative scenarios are generated using OSU Integrated Farm Financial Statements (IFFS) software (Doye, Petermann and Haefner 2000). In IFFS, cash shortfalls accumulate in the line of credit balance. The plans are based on a 35 head herd of moderate framed cows along with 1 breeding bull. Production assumptions are listed in Table 3. In the purchased cow scenarios, a cow/calf pair is initially purchased for \$2,800 and bull for \$3,600.

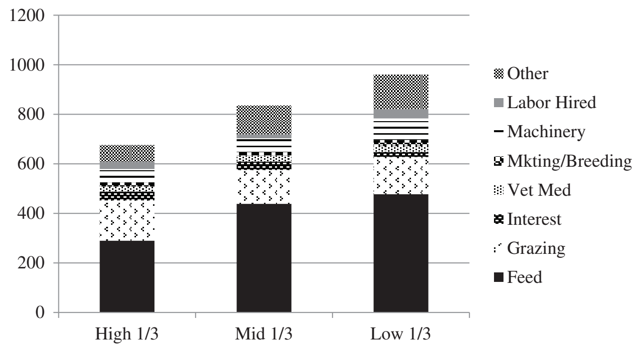


**Figure 1:** 2013 Variable cost of production by profit category (\$/cow), Kansas Farm Management Association

**Table 1:** Cow/calf herd assets included with different asset control strategies

| | Buy Land, Buy Cattle | Buy Land, Lease Cattle | Rent Land, Buy Cattle | Rent Land, Lease Cattle |
|---|---|---|---|---|
| Land: \$3,707/ha (\$1,500/a) | \$525,000 | \$525,000 | | |
| Cows: \$2,800/pair | \$98,000 | | \$98,000 | |
| Bull | \$3,600 | | \$3,600 | |
| Vehicle & trailer | \$23,500 | \$23,500 | \$23,500 | \$23,500 |
| Equipment | \$15,250 | \$15,250 | \$15,250 | \$15,250 |
| Supplies | \$2,000 | \$2,000 | \$2,000 | \$2,000 |
| Tractor | \$15,000 | \$15,000 | \$15,000 | \$15,000 |
| **Total** | **\$682,350** | **\$580,750** | **\$157,350** | **\$55,750** |

**Table 2:** Operating input costs for 35 cows on native pasture

| Operating Inputs | | Price | $ | Total | $ | Head |
|---|---|---|---|---|---|---|
| Pasture (rental) | $ | 150.00/head | $ | 5,250 | $ | 150.00 |
| Hay | $ | 32.55/head | $ | 1,139 | $ | 32.55 |
| Protein Supplement | $ | 63.22/head | $ | 2,213 | $ | 63.22 |
| Minerals & Salt | $ | 12.13/head | $ | 425 | $ | 12.13 |
| Vet Services/Medicine | $ | 5.77/head | $ | 202 | $ | 5.77 |
| Vet Supplies | $ | 14.86/head | $ | 520 | $ | 14.86 |
| Marketing | $ | 8.22/head | $ | 288 | $ | 8.22 |
| Mach/Equip Fuel, Lube, Repairs | $ | 147.71/head | $ | 5,170 | $ | 147.71 |
| **Total Operating Costs** | | | **$** | **15,206** | **$** | **434.46** |

Future calf and cull animal prices are important in determining the profitability of the enterprise. Table 4 shows projected calf and cull prices (Peel 2015).

## Alternative financing scenarios for establishing a 35 cow operation

In the U.S., financing of agricultural operations is primarily done by commercial banks, Farm Credit Services (a co-operative entity with quasi-governmental status), and private individuals. A USDA Economic Research Service report noted that these three groups held 95 percent of the debt outstanding at year-end as reported by farm operators for their businesses (Harris *et al.,* 2009). USDA's Farm Service Agency (FSA) guarantees many commercial loans and also makes some supervised direct loans to producers, primarily to beginning or socially disadvantaged farmers, who have been turned down for loans from commercial sources (www.usda.fsa.gov). FSA loan programs for which beginning farmers are eligible include a down payment program (DP), farm ownership loans (FO), joint financing arrangements, land contract guarantees, micro-loans and direct operating loans (OL). Beginning farmers generally receive preferential terms. Commercial lenders, both FCS institutions and agricultural banks, while interested in lending to younger and beginning operators typically do not offer concessionary programs. FSA loan program parameters are summarized in Table 5.

**Table 3:** Production parameters

| | |
|---|---|
| Production and price assumptions | |
| Cow weight | 499 kg (1,100#) |
| Bull weight | 794 kg (1,750#) |
| Weaned heifer weight | 220 kg (486#) |
| Weaned steer weight | 235 kg (519#) |
| Replacement heifer weight | 374 kg (825#) |
| Protein supplement (lb/hd/day) | 38% cubes |
| Cows | .68 kg (1.5#),150 days |
| Weaned heifers (Oct-Dec) | .68 kg (1.5#), 45 days |
| Bred heifers | .68 kg (1.5#), 150 days |
| Prairie hay (lb/hd/day) | $82.69/T ($75/ton) |
| Cows | 10.9 kg (24#), 30 days |
| Weaned heifers (Oct-Dec) | 5.9 kg (13#), 10 days |
| Bred heifers | 8.6 kg (19#), 30 days |
| Minerals | 0.05 kg (0.12#)/hd/day |
| Labor | 6.9 hours/head |

A total of 8 scenarios are evaluated: rent 142 hectares (350 acres) with either purchased or leased cows; purchase 81 hectares (200 acres) with an FSA FO loan and rent 61 hectares (150 acres); purchase 142 hectares (350 acres) using an FSA DP loan with purchased or leased cows; and purchase 142 hectares (350 acres) from a commercial lender with purchased or leased cows. In all cases, the beginning producer is assumed to be eligible for the FSA OL for financing operating inputs. Loan terms and associated cash flow parameters for our analysis are noted in Table 6. Commercial loan terms were based on an informal survey of several lenders. A presumed difference in scenarios is that the borrower has sufficient savings for the appropriate down payment.

Livestock leasing is much less prevalent than land leasing. Arrangements can be either cash or share leases. For the cow owner, leasing can generate income while reducing labour requirements. A cash lease provides fixed income for the cow owner, often on a per cow basis, with the cow operator incurring production risk. With a share lease, the cow operator may benefit from favourable production while the cow owner and operator share production risk and production decisions, which may complicate management. The leasing arrangement can be crafted to meet the goals of the cow owner and cow operator. One of the biggest decisions in a lease agreement is who is responsible for replacement livestock. Data shows producers cull around 14-15% of their cow herd each year (USDA APHIS 2012). The cow owner can be completely responsible for providing replacements; however, ownership of the cow herd does not shift over time in this arrangement. This type of agreement may be preferable if the cow operator wants to save money earned from the enterprise for purposes other than building a share of the herd or if the cow owner wants to stay engaged in the operation. Here, we

**Table 4:** Livestock price assumptions

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Steers, 5/6 cwt, $/kg ($/cwt) | 1.1 (243) | 1.25 (275) | 1.25 (276) | 1.72 (268) | 1.18 (260) |
| Heifers, 5/6 cwt, $/kg ($/cwt) | 0.99 (219) | 1.12 (248) | 1.13 (249) | 1.10 (243) | 1.07 (235) |
| Cull cows, $/kg ($/cwt) | 0.53 (118) | 0.57 (126) | 0.56 (124) | 0.54 (119) | 0.52 (115) |
| Cow/calf pair, $ | 2,800 | 3,300 | | | |
| Bull, $/head | | | 4,125 | | |

 

**Table 5:** Farm service agency loan programs for which beginning farmers are eligible

| Loan type | Term (years) | Interest rate | Down payment | Maximum loan |
|---|---|---|---|---|
| FSA Down Payment | 20 | 1.5% | 5% | The lesser of 45% of price, appraised value or $300,000 |
| FSA Farm Ownership | Up to 40 | 4% | None | $300,000 |
| FSA Joint Financing | Up to 40 | 2% less than FO or 2.5% | None | 50% by FSA |
| FSA Direct Operating Loan | 1-7 | 2.625% | 0 | $300,000 |
| FSA Microloan | 1-7 | 2.625% | 0 | $50,000 |

**Table 6:** Loan cash flow

| Loan Type | Years | Interest rate | Down payment | Annual Payment |
|---|---|---|---|---|
| FSA Down Payment (142 ha, 350 a) | 20 for FSA portion, 30 for remainder | 1.5% for FSA, 6% for remainder | 5% = $26,250 | $32,831 |
| FSA Farm Ownership (81 ha, 200 a) | 40 | 4.0% | 0 | $15,157 |
| Commercial (142 ha, 350 a) | 30 | 6% | 20% = $105,000 | $30,513 |
| FSA Direct Operating | 7 | 2.625% | | $21,498 with cows, $5,420 without cows |

**Table 7:** Plan for building the cow herd using leased cows

| Leased Livestock | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Cow/calf | 35 | 35 | 28 | 21 | 14 |
| **Beginning Operator's Owned Livestock** | | | | | |
| Replacement heifers | 9 | 9 | 9 | 9 | 9 |
| Bred heifers | | 7 | 7 | 7 | 7 |
| Cows | | | 7 | 14 | 21 |

**Table 8:** Net Cash flow available for new investment and risk with leased cows and leased pasture

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Calf sales | 14,965 | 16,983 | 19,774 | 21,916 | 23,865 |
| + Cull sales | | | 3,200 | 3,200 | 3,200 |
| - Cash expense | 12,324 | 15,624 | 16,626 | 16,891 | 17,164 |
| - Capital purchases | 34,250 | | | | |
| + New borrowing | 34,250 | | | | |
| - Debt service | | 5,420 | 5,420 | 5,420 | 5,420 |
| - Operating interest | 397 | 660 | 803 | 793 | 559 |
| Net cash flow | 2,244 | (4,720) | 125 | 2,012 | 3,921 |

assume replacement females will be retained and raised by the cow operator to build ownership in a cowherd.

Using the Beef Cow Lease Calculator, an equitable lease agreement is estimated to be a 0.67:0.33 share lease if all labour and inputs are provided by the cow operator and cows are initially provided by the cow owner (Dhuyvetter and Doye, 2013). Table 7 shows the cow-herd ownership transfer in the leased cow scenario with the livestock operator raising replacement females as allowed over time. As the cowherd ownership share for the cow operator increases, the operator provides more replacements and further grows ownership in the cow herd.

## 2. Results

The cash generated from calf and cull sales for the operation is significantly different during the five year projection horizon for leased and purchase cow scenarios (Tables 8 and 9). With leased cows, the cow operator has only a share of the calf crop and in addition is saving females for replacement heifers, leading to few calves to be sold. As the cow operator initially owns no cows, there are no cull sales in early years. Cash expenses for operating inputs for the leased cows are the same as those for purchased cows within a given scenario, except for taxes and insurance on owned cows. Excluding debt service, cash expenses are higher in scenarios with land rent (plus a small amount of additional operating interest expense). However, total cash outflows with land debt repayment are significantly higher than leased land scenarios. Highlighting the estimated debt service requirements and cash available to service debt makes apparent that the beginning producer will have a difficult time servicing debt without significant income from other sources.

The lease pasture and cows scenario shows growing positive cash returns to labour and management after three years when saved replacement heifers begin to generate income through calf sales. While the income is small, these returns can be used for herd expansion, farm business or off-farm investments, or applied to family living expenses. This alternative may work well for producers who are unable to borrow money for livestock purchases or prefer to minimize debt. The cow operator

**Table 9:** Net cash flow available for new investment and risk with purchased cows and pasture purchased using a commercial Loan

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Calf sales | 29,086 | 30,993 | 31,020 | 30,161 | 29,236 |
| + Cull sales | 1,298 | 9,702 | 15,093 | 12,363 | 12,055 |
| - Cash expense | 10,775 | 14,461 | 14,491 | 14,498 | 14,483 |
| - Capital purchases | 555,850 | 3,300 | 4,125 | | |
| + New borrowing | 555,850 | | | | |
| - Debt service | | 52,010 | 52,010 | 52,010 | 52,010 |
| - Operating interest | 300 | 1,880 | 3,308 | 5,116 | 7,008 |
| Net cash flow | 19,309 | (30,956) | (27,821) | (29,099) | (32,210) |

builds equity and collateral as herd ownership grows. In seven years, the cow operator has fully transitioned to owning a 35 cow herd.

In other scenarios where cattle and land or both are purchased with borrowed money, sales are generally sufficient to cover cash operating expenses and contribute to either land or cattle loan payments; however, the income generated is generally not enough to cover all of the cattle loan payments and certainly not enough to cover all land payments. Hence, an off-farm job or outside income is necessary to meet loan obligations and avoid rolling over the line of credit. Figures 2 and 3 compare net cash flow for different land control alternatives. The pattern intra-year is similar between the two but with a different scale.

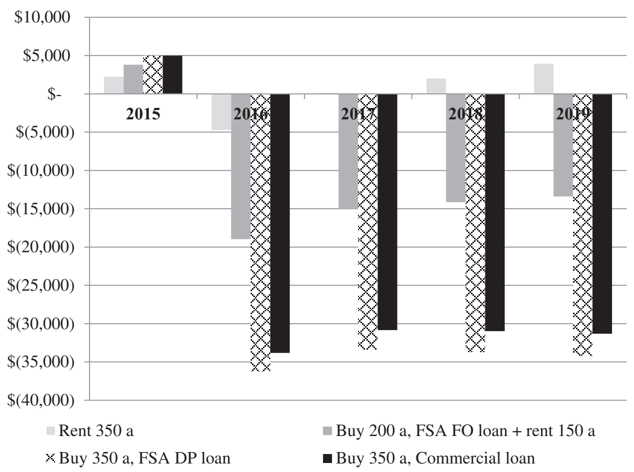


**Figure 2:** Net cash flow with alternative land controls and leased cows

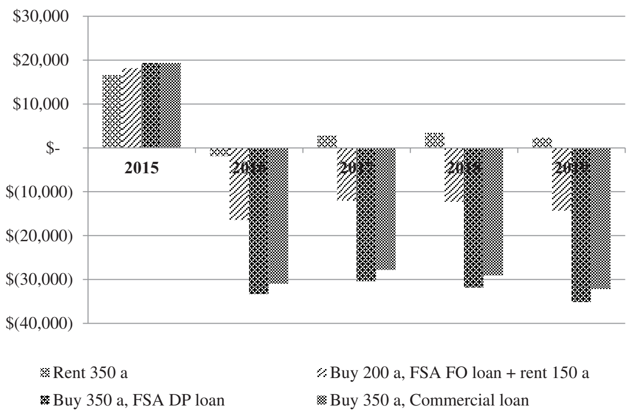


**Figure 3:** Net cash flow with alternative land controls and purchased cows

Because of the limited cash generated, leasing cows while purchasing land is not a good combination in early years; over time, however as cow ownership increases without associated cow debt, cows help with cash flow and reduce net cash shortfalls. Cash flow improves over time in the land control alternatives with leased cows (Figure 2); on the other hand, the debt burden with both purchased cows and purchased land does not allow for much improvement until cows are paid for after 7 years. This becomes more transparent when the operating line of credit end-of-year balance representing outside income or borrowing capacity needed to pay operating expenses and make loan payments is compared for different scenarios (Figure 4). Higher credit line balances are needed in purchased cow scenarios for a given land control scenario.

The net cash flow associated with buying 350 acres with an FSA DP loan and a commercial loan is similar. Recall that a significantly larger down payment is required for the commercial loan ($105,000 compared to $26,250) and the average interest rate is higher. But, the term is shorter on the FSA DP portion of the borrowing resulting in a higher average loan payment and worse cash flow consequences.

In Figure 5, total debt over time is plotted to provide a visual of the debt levels associated with different scenarios and the changes over time. Buying 350 acres of land commits the producer to high levels of debt for

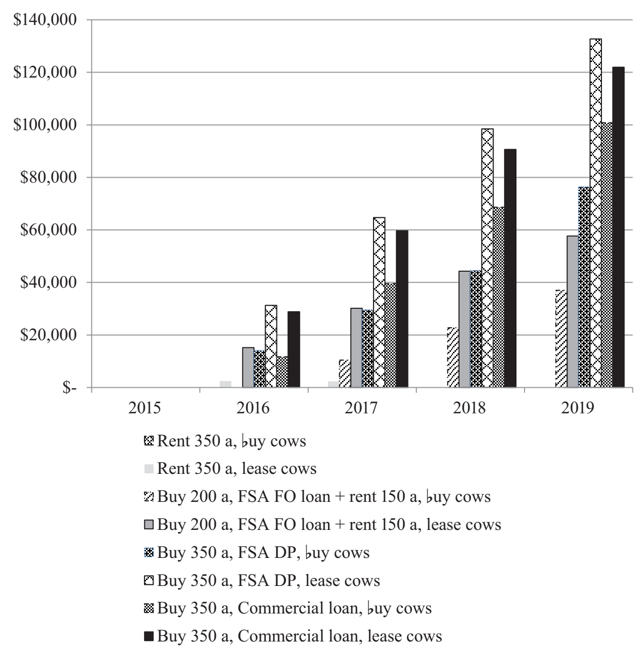


**Figure 4:** Line of credit balance for different scenarios

 

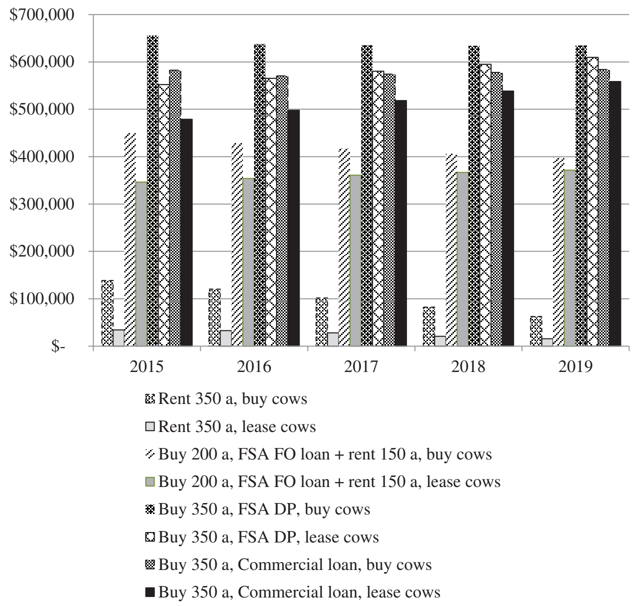


**Figure 5:** Total debt associated with different scenarios

decades but builds equity over time if the ranch is profitable and/or land values appreciate.

## 3. Summary and conclusions

With each Census of Agriculture, concerns are voiced about the aging farm population and the repercussions of few young farmers entering the profession. High calf prices, low cowherd numbers, growing market opportunities, and lessening drought conditions seemingly point to profit opportunities for new livestock producers. However, finding financially feasible means of entry remains a challenge. Leasing cows and land for beginning producers is a promising proposition. Producers who are short on cash for a down payment or are not credit worthy may consider leasing cows and land as a way to enter ranching. The cow operator builds equity and collateral as ownership in the cowherd grows. Leasing cows is a financially feasible, if slow, path to cow ownership. However, if income is available from other sources, purchasing cows may be preferred. A beginning producer with excellent management skills and low costs of production may be able to generate sufficient cash flow to cover operating expenses and contribute to loan repayment. But, making land payments will require significant off-farm income. This research provides insights for beginning producers, extension educators, and lenders regarding the possibilities and challenges to entry that beginning producers face in establishing cow herds.

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# Development of a dairy industry in a new area – land use change in Canterbury, New Zealand

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**ABSTRACT**

Canterbury dairying increased from 20,000 ha in 1980-81 to 255,000 ha in 2013-14. During this time, Canterbury production increased from 2% of New Zealand's milk to 19%. This paper examines factors that influenced this increase. The analysis draws on case studies of industry participants, a survey, and secondary data.

There were three waves of development. Wave 1 (1980s) farmers were entrepreneurs who saw Canterbury as a desirable place to live with new economic opportunities related to dairying. Wave 2 (1990s) convertors were a mix of corporate entities and traditional sheep/crop farmers who aimed to increase farm profitability. Wave 3 (since 2000) convertors have included cropping farmers and expanding dairy farming businesses developing large, intensive farms. This wave included substantial investment from non-farmers, particularly through equity partnerships.

The research identified growth factors that could be classified as enablers, drivers, and facilitators – with some factors fitting into more than one classification. Enablers were necessary for growth but by themselves did not create the growth. In contrast, drivers were the fundamental determinants of growth. Facilitators were factors that did not either enable or drive growth, but did influence growth.

Enablers included aspects of the political and economic environments. These included new institutional sources of finance. The prior existence of a local processing cooperative and an established vertically integrated supply chain were also of critical importance.

Drivers of land change included changing levels of profitability between farming systems, the development of a new resource (irrigation) and the perceived potential to grow wealth through business growth and thereby fulfil personal objectives. Increased industry profitability then fuelled further development.

New irrigation technologies were both enablers and facilitators. Extension, consulting and the development of input supply companies were all important facilitators.

**KEYWORDS:** Canterbury dairy industry; agricultural industry development

## 1. Introduction

In the 1960s and 1970s, dairying in Canterbury was a minor industry. There was a town supply industry (fluid milk), plus some small butter and cheese factories. Dairy cows were farmed predominantly on heavy soils such as clay and silt loams. The light lands of the Canterbury Plains were used for sheep production. On the medium soils, the predominant land-use was a mix of sheep, wheat, barley, white clover seed and grass seed. It was in the 1980s that dairy production began to increase.

By 2014 the area in dairying had increased to 255,000 ha from 20,000 ha in 1980. (LIC[3] 2014). In the 1980s, Canterbury production averages per cow and per hectare were lower than for the more established North Island industry. However, by 2014, Canterbury produced the highest level of milksolids (ms) per hectare of any region in New Zealand, at 1,375 kg ms/ha compared to 1,063 kg ms/ha for New Zealand overall. Per cow production of 395 kg ms compared to 371 k ms for New Zealand overall. On a national basis, Canterbury production has increased from 2% of New Zealand's milk in 1982-83 to 19% in 2013-14, even though national production has itself increased. An earlier empirical description of some of these changes was presented at IFMA18 (Pangborn and Woodford, 2011).

Ministry of Agriculture and Fisheries (MAF) models for 2010-11 show income and expenses per kg milksolids, and hence operating surplus per kilogram of milksolids, as being similar for Canterbury and the rest of New Zealand (MAF 2010-11). However, because of higher production per hectare, Canterbury operating surpluses per hectare were greater than elsewhere in New Zealand.

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[3] LIC is the trade name of the Livestock Improvement Corporation. The LIC is a cooperative providing herd testing and genetics to the dairy industry..

In contrast, historical DairyNZ data indicated that per hectare operating surpluses had been greater in some years only, and either similar or less in other years (DNZ 2010).

Pangborn (2012) calculated from MAF data that in the first decade of this century returns on capital (debt plus equity) were greater in Canterbury than the rest of the country (9% compared to 4%). DairyNZ (DNZ 2012-13) has reported that Canterbury farms in 2012-13 achieved an EBIT (earnings before interest and tax) return on assets of 12.1% compared to a New Zealand average of 9.2%.

## 2. Research methods

An initial model of industry development was constructed from prior literature (Figure 1). Influential authors were Porter (1990, 1998), Schumpeter (1961, 1982), Van de Ven and Garud (1989), and Van de Ven et al. (1989). None of these studies was specific to agriculture. Prior literature which was specific to agriculture included Woods et al (1994).

The key data sources were semi-structured interviews with 35 farmer and non-farmer industry participants from throughout the industry value chain. The main focus was on getting participants to tell their own story as to what they had done and why they had done it, together with broader observations of the industry. Interview prompts were developed from the proposed factors (Figure 1) but in the main the interviewees simply told their 'what and why' story in a discussion framework with the interviewer and in a chronological order. This information and the interpretation thereof was supplemented by insights from an unpublished farmer survey that helped inform the role of extension in promoting growth and the adoption of innovations. Also, the authors have themselves, as local university academics, all been observers of the Canterbury industry. Further, the first author has direct experience over more than 28 years as a practicing Canterbury dairy farmer. The authors therefore acknowledge their own background as shaping the direction of the investigations, while taking care to ensure that all interpretations are evidence-based. More details on methods are reported in Pangborn (2012).

## 3. Results

### Waves

The notion of development waves was an emergent theme from the interviews. In Wave 1 (1980s), farmers tended to be driven by entrepreneurial motives and were often moving from another dairy region that was not considered as favourable. They were able to purchase larger blocks of irrigated land at a lower cost than in other dairying areas. Considerable entrepreneurial profits were achieved.

In Wave 2, (1990s) many conversions were completed by corporate entities. Due to the low operating profits of that period, these corporate farmers had largely left the industry by the late 1990s. In doing so, they sold many of their farms to their sharemilkers, thus creating a new generation of farm owners. However, there were also traditional sheep and crop farms in this wave who were converting to obtain higher levels of profitability than were available in their industry.

In Wave 3, since 2000, new dairy farmers have tended to be established farmers from other sectors such as cropping, or expanding dairy farming businesses, who purchased and converted to dairy farming for economic reasons. The rate of growth was influenced by enthusiastic lending to dairy farmers by the primary and secondary financial institutions. Wave 3 farmers tended to develop large and more intensive farms. This wave also saw investment from non-farming investors, particularly in equity partnerships.

### Factor conditions

A comparison of the findings to Figure 1 confirmed the role of entrepreneurs, particularly in Wave 1. Most informants suggested that the early converters captured significantly more entrepreneurial profits than the later waves. Several Wave 1 participants stated that the pre-purchase analysis of the cost of purchase and conversion was not always rigorous.

Although it would seem logical that Canterbury productivity could be higher than elsewhere in New Zealand due to irrigation, production and profit were similar until the new century. A number of informants suggested that the major research and extension providers were not interested in the industry until the Lincoln University Dairy Farm (LUDF) was initiated in 2001 (Wave 3). Although a number of factors would influence productivity, informants suggested that there was a positive effect on production and profitability from the establishment of the LUDF.

Informants did not consider that there was a large involvement of government in the development of the Canterbury industry. However, there was recognition that the major growth occurred after the removal of most government support for agriculture in the 1980s. The removal of price supports, particularly to the sheep and cropping industries in 1984 (Rayner, 1990), meant that these farming systems became less economic and, so were more likely to be sold or converted to other farming systems such as dairying. The loss in profitability of the historic sheep and cropping systems was a major driver of development. In general, farmer informants focused on 'close to farm' factors and did not identify, without prompting, the efforts of government in international trade negotiations or changes in international markets.


**Figure 1:** Proposed factors in the development of the Canterbury dairy industry

The economic conditions of the times led to change. The restructuring of the New Zealand economy caused land prices to fall in the late 1980s, which increased opportunities for established and new land owners. Since the restructuring, farmers have not been able to 'farm subsidies' and, in the opinion of informants and the survey participants, farmers have focused on production and profitability. As well as removing farm price supports, the financial industry was deregulated late in Wave 1. A number of informants discussed the difficulty in obtaining finance in Wave 1, but were able to source capital more easily in Wave 2 and some suggested that the financial institutions were too liberal in Wave 3.

A number of informants expressed the advantages of being involved in large vertically integrated processing/marketing cooperatives. In particular, the success of the processing cooperative (Alpine Dairy Products) allowed growth in Wave 2. The company coped with ever increasing volumes of milk, financing new processing capacity and dealing with pesticide and quality issues. However, a number of informants questioned whether Alpine would have been successful without the support of the state sanctioned New Zealand Dairy Board. Several sources suggested that a cooperative was necessary for development of the industry in Waves 1 and 2, as proprietary companies would not have been prepared to spend the time and money necessary to solve the problems that arose.

Innovation and new technologies were considered important. In Waves 1 and 2, innovations in irrigation technology allowed deeper wells, with more labour and water efficient delivery systems. Other factors that contributed to growth in Wave 2 were improved methods for organizing the farm layout and cowsheds, and management techniques for large herds. The most widely adopted technology introduced by the LUDF (low grazing residuals) was suggested to have improved profitability in Wave 3 by some informants and survey participants.

## Additional factors discovered by research

The more intensive use of the irrigation resource was considered an important factor in development. Although irrigation had been part of Canterbury farming since the 1940s, it was often seen as a means of coping with drought rather than as a means of increasing farm output. Stewart's (1963) findings that irrigation in itself did not improve farm returns under the farming systems of the time (sheep/cropping) were prophetic when the subsidies supporting these farming systems were removed at the start of Wave 1. Thus, if a farmer had irrigation he was often driven to either convert or sell his property due to the superior relative economics of the dairy industry - either way there was a financial gain and dairy industry growth.

Human reasons were important, particularly in Waves 1 and 2. The developing dairy industry in Canterbury presented individuals with the opportunity to purchase farms with the hope of more stable production through irrigation. Informants suggested that Wave 1 converters often moved to Canterbury to improve social and educational opportunities and for the challenge of being part of something new. The lower price of land was an attraction; particularly for North Island farmers who could purchase twice as much land in Canterbury with the funds from the sale of their North Island farm. In reality, farmers in all waves moved for the human reasons of improving their lives and financial position.

The motive of capital gains and profit encouraged corporate farmers to invest in what they considered to be 'cheap land'. Informants commented that corporate farmers developed improved methods for converting farms to dairying, were more financially disciplined and instilled in farmers a positive attitude to multiple farm ownership. Although the initial entities departed the industry within ten years due to low operating profits, they left a legacy of alternative business structures to traditional family farms. These included what is described as 'family corporates' and 'equity partnerships'.

The availability of land for supporting the dairy industry was important for industry growth from Wave 2. These blocks allowed a higher stocking rate by removing the replacement heifers from the 'milking platform'. In addition, support blocks became important for grazing cows in the winter and for the production of supplementary feed. Winter grazing and higher levels of supplementation were an integral aspect of the development of a Canterbury dairying system versus traditional self-contained systems.

One of the defining features of the Canterbury dairy industry is that the development has contained elements of resource development, elements of changing land use, and elements of system configuration, together with knowledge transfer from other locations. There was no new product development; rather it as a situation of adapting dairy production systems for a new contextual environment. This is in contrast to much of the industry development literature which focuses on new products.

## A new model

The review of literature on industry development led to Figure 1. In contrast, the case studies and survey of industry participants have led to a new model (Figure 2). This model proposes that within the waves, the relevant factors act in different ways and are best considered within a framework of enablers, drivers, and facilitators of growth. In some cases, the factors fit into two categories. Enablers were defined as factors that were necessary for growth but did not themselves create the growth. In general they relate to the broader political, economic and regulatory environment. Drivers are defined as fundamental factors, typically related to prices and resource availability that caused the growth to occur. Facilitators are defined as factors that had a positive influence on growth, and typically made the growth process more efficient.

Low land prices in Wave 1, encouraged entrepreneurial dairy farmers to purchase land in Canterbury to convert to dairy farming. The lack of profitability in other farming systems drove sheep and cropping farmers to sell their land at low prices. A further driver was the human reasons of establishing an often larger farm in an area seen to have social advantages. Although the development of the irrigation resource was an enabler, it can also be seen as a driver. Informants suggested that once water was added to a property, the highest economic use was as a dairy farm. Wave 2 saw the entry of corporate farmers as industry drivers. With more secure sources of capital and improved farming systems, the corporates converted many farms in pursuit of capital gains. In Wave 3, increased profitability in the dairy industry drove further conversions.

Enablers were the factors that were necessary for the growth to occur. In Wave 1, these included government

 

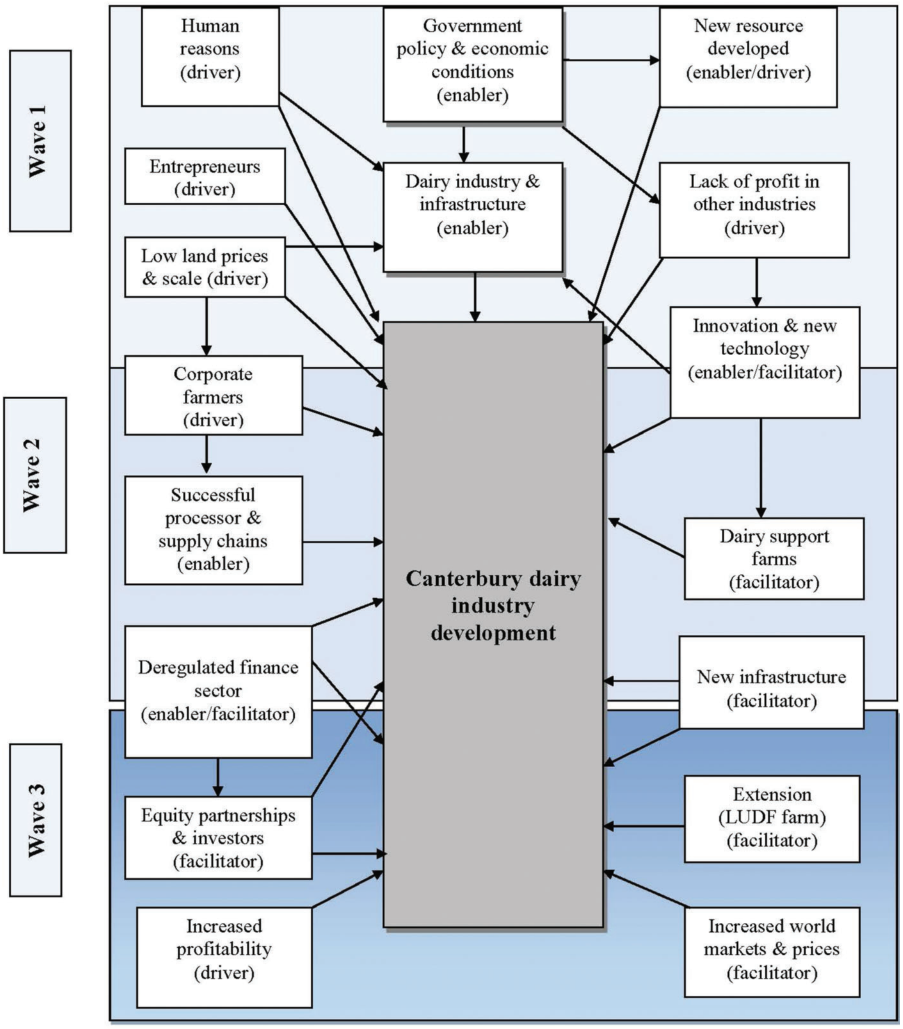


**Figure 2:** Interrelationships of drivers, enablers and facilitators in the development of the Canterbury dairy industry

policies and economic conditions which, in this case, followed the economic restructuring of the New Zealand economy. A further enabler was the industry infrastructure already in place which allowed faster growth, by removing many of the steps necessary for the development of a new industry. The development of the processing cooperative in Wave 2 was an important enabler, as without the ability to process all the milk produced, growth would have slowed. The finance industry became an enabler of growth in Wave 2 and a facilitator of industry growth in Wave 3 through liberal lending policies.

In Waves 1 and 2 the development and adoption of new technology was an important enabler and facilitator. Informants suggested that improved irrigation technology, cowsheds, farm layouts and machinery were important. Other than irrigation, these technologies were available to the rest of the industry, but were more readily adopted by an area ‘starting from scratch’ with larger land areas.

Facilitators, although not driving or enabling growth, had positive influences. Most of the facilitators were found in Waves 2 and 3 and included new input suppliers, farms that dedicated their system to supporting dairy farms and new business structures that assisted the sourcing of capital for a ‘capital hungry’ industry. The LUDF was a facilitator in Wave 3 that provided a forum for information and discussion that was one of a number of factors in the productivity and profitability increases. A further facilitator was the trend to increasing milk prices, particularly in Wave 3, a result of increased global demand.

## 4. Conclusions

The development of the Canterbury dairy industry is a consequence of the coalescence of a multiplicity of factors. The profitability of dairying, both in absolute terms and also relative to product prices for competing land uses, was a driver of fundamental importance. Also, the ongoing development of irrigation, which had commenced in much earlier times, helped to create a bio-physical environment that was well suited to pastoral dairying. However, by themselves these would not have been sufficient to create a new industry. First, there had to be a group of entrepreneurial innovators who were prepared to take the first steps and the associated risks in the search for personal fulfilment. Institutional factors, relating in particular to finance and the regulatory environment were then necessary for these innovators and their early followers to be able to operate. Farm input firms had to develop alongside the development of the farms themselves. Also, in the absence of a farmer co-operative the necessary processing facilities may never have developed. Similarly, the presence of the New Zealand Dairy Board, which in those times took responsibility for marketing of products, was of major importance in the early stages. Given this multiplicity of factors, any industry policy person who wishes to encourage industry development needs to have a 'whole of system' enabling perspective. Industry development can be constrained by the absence of any one of the many necessary factors.

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CONFERENCE PAPER

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# Impact of the 2014-2020 CAP reform on the economic performance of Polish farms

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**ABSTRACT**

This paper deals with potential impacts of the recent CAP reform on crop production structure and economic results of Polish farms in the perspective of the year 2020. The focus of the assessment was on the 'greening' component, which is the key element of the reformed policy. The assessment was made with the use of static farm optimization model. Model results show that the reformed CAP on average will have a positive impact on farm incomes. A decrease in farm income can be seen, however, in certain types of farms that require major adaptations in order to fulfil the greening criteria, mainly establishing 5% of the Ecological Focus Area. Some changes in the cropping structure may be expected because of greening, mainly slight reduction of the share of cereals and a greater area of legume crops.

## 1. Introduction

Since its establishment, the Common Agricultural Policy (CAP) has undergone successive reforms. One of the most important changes in the history of the CAP was de-coupling (EC 2011a) that shifted support from product to producer by assigning a payment to the area of agricultural land in order to eliminate distortions in international trade in agricultural commodities. The most recent CAP reform, shaping agricultural policy of the EU for the period 2014-2020 introduced the 'greening' concept which, although not expressly stated, was legitimization of financial support for agriculture and response to public expectations within the EU.

In the original proposal of the European Commission of November 2011(EC 2011b) the 'greening' requirements for all farms with more than 3 hectares of arable area (AA) were presented:

- minimum three crops in rotation (one crop maximum 70% share, 5% minimum share of the AA);
- maintaining at least 95% of permanent grassland,
- designating 7% of AA for ecological focus areas (EFA).

Considering those criteria 88% of Polish commercial farms[2] met the crop diversification criterion. Majority, 74% of farms had adequately diversified crops structure, but without the required EFA.

In the final version of the reformed policy the original 'greening' proposal was significantly modified (EU Parliament 2013). Farms having less than 10 ha of AA and all ecological farms have been exempted from the 'greening'. For farms below 30 ha only 2 crops were required (max. share of 75%). Farms below 15 ha of arable land have been released from establishing EFA. The minimum EFA for larger farms has been set as 5% of AA. Additionally a set of practices equivalent to EFA has been introduced. For example, in Poland 1 ha of nitrogen fixing crops substitutes 0,7 ha of EFA. Taking into account final regulation 57% of Polish farms will be exempted form new obligations, 23% fulfil the criteria, in 18% some EFA deficits could be observed and 2% do not meet crop diversification criterion.

The 'greening' concept has been criticized by numerous authors (Pe'er, 2014). They point out that the majority of EU farmers work on farms smaller than 10 hectares, so they will be exempt from the greening. Therefore 'greening' will not have a positive impact on the environment or biodiversity protection, which were original objectives of this concept. Ciaian *et al.* (2013) state that 'greening' will cause an increase in costs, thus reducing farm incomes. The authors point out that in fact the impact of the CAP 'greening' can vary greatly due to the existing diversity in the structure of production, specialization, geographical location and technology of production in agricultural holdings. Some researchers predict that the 'greening' will result in increases of prices of agricultural commodities. This would compensate additional costs of adaptation to the new requirements (DEFRA 2013).

The objective of this paper is to assess impacts of the recent CAP reform on crop production structure and economic results of Polish farms in the perspective of the year 2020.

## 2. Research Methodology

In order to determine the impact of the final form of the CAP 'greening' the baseline scenario and two scenarios for reformed agricultural policy have been developed.

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[2] Based on Farm Accountancy Data Network (FADN) criteria for year 2009, Standard Gross Margin higher than 2400 EUR/farm/year

To assess production and economic impacts of their potential implementation non-linear optimization model was applied. The results obtained by the modelled farms were aggregated in order to determine the impact of the agricultural policy scenarios on economic results obtained in the different types of farms and FADN regions.

The Farm-Opty optimization model with non-linear cost function using the Positive Mathematical Programming method (Howitt R.E. 1995) was used. The model is based on the assumption that farmers maximize farm income, as it is shown in the following equation:

$$\underset{x_i \geq 0}{DR} = \mathrm{p}^T(\mathrm{x} \bullet \mathrm{y}) + \mathrm{s}^T\mathrm{x} + fs - fc - \mathrm{d}^\mathrm{T}\mathrm{x} - \mathrm{x}^\mathrm{T}\mathrm{Q}\mathrm{x}$$

***provided that*** $\boldsymbol{Ax \leqslant B}$
where:
*DR – agricultural income,*
*p – products prices,*
*y – yield and productivity,*
*x – levels of production activities,*
*s – payments for production activities,*
*fc – relatively fixed costs,*
*fs – value of the payments,*
*A – resource utilization coefficients,*
*B – available resources,*
$d^Tx\text{-}x^TQx$ *– non-linear element determined in the model calibration.*

This model builds on the classical linear optimization problem used in farm models (Was, 2005). Introduction of PMP limited number of data required and solve over-simplification of LP models solutions. In order to verify the requirement of crop diversification in each type of farm Shannon-Weiner's index was used (Shannon, 1948).

### Scenarios considered

**A. Base_2012 and Baseline_2020**

The scenarios assume a continuation of the current CAP. The BASE_2012 scenario was used only to calibrate the models, whilst baseline is a point of reference for other scenarios. The BASELINE_2020 scenario assumes that the existing in 2014 CAP mechanisms will remain unchanged.

**B. Green_2020**

In this scenario the requirements arising from the CAP 'greening' are implemented, entitling farmers to direct payments amounting EUR 184 per hectare.

Additional, newly introduced payments (MARD 2014) are also modelled:

- for young farmers - 62 EUR/ha for first 50 hectares.
- for farmers owning 3.01-30 hectares receive additional 41 EUR/ha.
- related to production:
  - for cattle for farmers having at least 3 bovine animals aged up to 24 months up to the 30th one - 70 EUR/head,
  - for cows – like the above,
  - for sheep and goats 25 and 15 EUR/head respectively,
  - for soft fruit – to strawberries and raspberries – up to 250 EUR/ha.
  - for protein crops –grown as the main crop up to 326 EUR/ha (digressive from 75 ha).

**C. No_Green_2020**

The scenario implies giving up 30% of direct payments, by farms non-adapted to greening requirements (EUR 74/ha). Farms exempted from 'greening' and fulfilling all the requirements would receive direct payments, and other support equal to those assumed in the GREEN_2020 scenario.

Both Green Scenarios assume that inclusion of the 'greening' component will result in decrease in funding of agri-environmental activities under the 2nd pillar, from EUR 2.304 billion provided for in RDP 2007-2013 to EUR 1.060 billion provided for in RDP 2014-2020. Thus the existing agri-environmental payments will be reduced also by 46% per average farm which will be the subject of modelling. LFA[3] payments were assumed in all the scenarios under consideration at the level used to date.

## 3. Research Sample

Polish FADN[4] was the main source of data. The 2012 data were used to develop a typology and prepare parameters for farm models. The data set consists of 10,909 research objects (individual farms). The entire population of farms was divided into production types according to Community typology of agricultural holdings of 2009. The population of the FADN (farms represented by the FADN sample) includes 735.5 thousand farms, which accounts for 50% of all farms in Poland. The farms covered by the FADN system produce about 90% of the total value of output in the agricultural sector, and have 81% share in the total agricultural area in Poland.

### Typology of farms

The farms for modelling were identified based on the following three criteria:

- area of agricultural land,
- production type (field crops, cattle, pig, mixed, other),
- degree of adaptation to the 'greening' requirements.

According to the key criterion - degree of adaptation to the 'greening' requirements the following farm types were distinguished:

- Exempted from 'greening' – <10 ha AA and organic,
- 'Green' – meeting all requirements,
- No diversification – failing to meet the crop diversification requirement,
- No EFA – having insufficient EFA
- No EFA and diversification – failing to meet both above requirements.

The results obtained after application of these criteria are shown both as a whole (for the entire FADN population), and taking into account the individual FADN regions (Figure 1).

The structure of farms belonging to the FADN population, determined based on the adopted typology is shown in Table 1.

[3] Less Favoured Areas
[4] Farm Accountancy Data Network – the EU system of gathering accountancy data from the sample of farms in EU; http://ec.europa.eu/agriculture/rica/


**Figure 1:** FADN regions

The majority of Polish farms fulfil the crop diversification criteria. Non-compliance with the 'greening' requirements applies to 20% of the farms from the population represented by FADN, with insufficient EFA being the major reason. The percentage of non-adapted farms is different among regions. The greatest numbers of non-adapted farms are to be found in the regions characterized by the largest average area of farms. In areas where farms are relatively small, there is the largest proportion of farms exempt from the 'greening' requirements. The least adapted to the 'greening' are farms specialized in field crops and pig farms.

As many as 229 farm types were ultimately designated to be modelled taking into account their geographical location, the criterion of production scale and production type, as well as their adaptation to the 'greening' requirements.

## 4. Results

The implementation of the 'greening' requirements in model farms has a noticeable impact on transformations in the cropping and crop production structure (Table 2).

Transformations in the crop structure result from the restrictions on the number and share of crops and the need to withdraw from production some arable land to create the required are of the EFA. However, the possibility of applying practices equivalent to EFA mitigates an impact of the CAP 'greening' on the crop structure. In the GREEN_2020 scenario the shares of all main crops are decreased, affecting mostly cereals, reduced by 2 percentage points.

The share of legumes is increased in the model solutions for both 'green' scenarios due to the introduction of an EFA equivalent which provides for recognizing 70% of the area on which legumes are cultivated as EFA. In the NO_GREEN_2020 scenario, although there is no need to establish EFA the increase in the area under legumes results from subsidies for its production. Relative changes in farm incomes presented in table 3 are average values for farm types modelled after aggregating model results.

The results of model solutions account for the combined impact of the three major innovations in the set of mechanisms provided for in the reformed CAP – 10% increase in the Polish direct payments envelope compared to the previous financial EU budgetary framework, 'greening' and additional payments for small and medium-sized farms, including subsidies for livestock production.

An average Polish farm would benefit under the GREEN_2020 scenario due to the implementation of the CAP reform by nearly 5% relative to the BASELINE_2020 scenario. Incorporating the 'greening' mechanism in the system of direct payments in Poland has a small impact on agricultural income, which is due mainly to the fact that a significant proportion of farms are exempt from the 'greening' requirements or satisfy them sufficiently. The farm income of farms which need adjustments is slightly decreased, on average inefficient those farms that have no sufficient EFA or do not meet both, the EFA and diversification criteria.

Model results show some differences across the various farm types. In geographical terms the undoubted beneficiaries of the reformed CAP are farmers from the regions of Mazovia and Podlasie, as well as those from

**Table 1:** Structure of farms represented in the FADN population [%]

| | Exempted | 'Green' | No EFA | No diversification | No EFA and diversification |
|---|---|---|---|---|---|
| Poland | 57 | 23 | 18 | 1 | 1 |
| By FADN region | | | | | |
| Pomerania and Masuria | 44 | 27 | 26 | 1 | 2 |
| Greater Poland and Silesia | 42 | 25 | 29 | 1 | 3 |
| Mazovia and Podlasie | 58 | 24 | 16 | 1 | 1 |
| Lesser Poland and Pogórze | 80 | 14 | 6 | 0 | 0 |
| By production type | | | | | |
| Field crops | 36 | 30 | 30 | 1 | 3 |
| Cattle | 61 | 20 | 18 | 0 | 1 |
| Pig | 36 | 24 | 33 | 2 | 5 |
| Mixed | 59 | 23 | 16 | 1 | 1 |
| Other | 93 | 3 | 2 | 1 | 1 |
| POLAND | 57 | 23 | 18 | 1 | 1 |

*Source*: The authors' compilation based on FADN data.

**Table 2:** Changes in the crop structure in the model solutions within the ''greening'' scenarios

| Item | BASELINE_2020 | | GREEN_2020 | | NO_GREEN_2020 | |
|---|---|---|---|---|---|---|
| | Area [ha] | [%] | Area [ha] | [%] | Area [ha] | [%] |
| TOTAL | | | | | | |
| Wheat | 2.26 | 16.4 | 2.21 | 16.0 | 2.25 | 16.2 |
| Other cereals | 7.96 | 57.5 | 7.69 | 55.9 | 7.90 | 56.9 |
| Cereals-total | 10.23 | 73.9 | 9.89 | 71.9 | 10.15 | 73.1 |
| Legumes | 0.39 | 2.8 | 0.61 | 4.4 | 0.58 | 4.2 |
| Rape | 0.72 | 5.2 | 0.69 | 5.0 | 0.71 | 5.1 |
| Other crops | 2.14 | 15.5 | 2.04 | 14.8 | 2.13 | 15.4 |
| EFA | 0.37 | 2.7 | 0.52 | 3.8 | 0.31 | 2.2 |
| Total | 13.84 | 100 | 13.75 | 100 | 13.88 | 100 |

*Source*: The authors' compilation.

Lesser Poland and Pogórze, in which small farms dominate. The majority of farms in these regions are exempted from the greening restrictions and at the same time they benefit from the newly introduced additional payments, that are in favour of small farms.

Analysis of the impact of the reformed CAP on the various farm types leads to the conclusion that cattle and mixed farms benefit most from the new CAP. This is largely due to the high level of conforming to the 'greening' requirements and the introduction of subsidies for cattle production. In the other farm types, the reform of the CAP has nearly no influence on incomes.

Farm incomes of small farms up to 15 hectares of arable land will increase by about 8% in relation to the BASELINE_2020 scenario and large farms will be affected by the consequences of the reforms. Farm incomes in farm size clusters of 15-30 hectares and more than 30 hectares decrease by 1,2% and 5,7% respectively.

Resigning from the 'green' portion of direct payment in the NO_GREEN_2020 scenario is not profitable for farmers. It is particularly disadvantageous for field crop farms and pig ones due to their relatively large average area and a high share of cereals.

Compared to the BASELINE_2020 scenario, the share of subsidies in farm income increases in all farm types under consideration, mainly due to the increased envelope of direct payment for Poland in the EU payments convergence process. The share of subsidies in income under GREEN_2020 scenario greater, compared to the BASELINE_2020, in all types of farms.

As expected, rejection of the adjustments and abandoning the 'green' portion of the payment under the NO_GREEN

**Table 3:** Changes in farm income and share of subsidies in farm income under considered scenarios

| Farm types | Farm Income BASELINE_2020=100 | | Share of payments in Farm Income [%] | | |
|---|---|---|---|---|---|
| | GREEN 2020 | NO_GREEN 2020 | BASELINE | GREEN 2020 | NO_GREEN2020 |
| Production type | | | | | |
| Field crops | 100.6 | 94.8 | 44 | 46 | 41 |
| Cattle | 109.2 | 106.1 | 35 | 40 | 38 |
| Pig | 100.3 | 97.6 | 21 | 22 | 19 |
| Mixed | 106.6 | 102.2 | 51 | 55 | 52 |
| Other | 99.4 | 100.8 | 20 | 22 | 21 |
| Farm area | | | | | |
| I<10 ha AA* | 107.6 | 107.6 | 52 | 55 | 55 |
| 10 ha<II<15 ha AA | 107.5 | 108.0 | 48 | 52 | 51 |
| 15 ha<III<30 ha AA | 106.5 | 98.8 | 43 | 48 | 42 |
| IV>30 ha AA | 100.2 | 94.3 | 33 | 35 | 29 |
| Adaptation to the ''greening'' requirements | | | | | |
| Exempted | 107.0 | 107.0 | 55 | 57 | 57 |
| Green | 110.3 | 110.4 | 50 | 54 | 54 |
| No EFA | 95.0 | 97.4 | 33 | 36 | 28 |
| No diversification | 101.5 | 93.3 | 18 | 22 | 16 |
| No EFA and diversification | 97.8 | 92.1 | 31 | 34 | 25 |
| Region | | | | | |
| Pomerania and Masuria | 102.2 | 98.3 | 37 | 39 | 36 |
| Greater Poland and Silesia | 103.1 | 98.6 | 37 | 41 | 36 |
| Mazovia and Podlasie | 107.6 | 103.4 | 51 | 55 | 52 |
| Lesser Poland and Pogórze | 104.1 | 102.1 | 39 | 42 | 40 |
| POLAND | 104.6 | 100.7 | 42 | 46 | 42 |

* AA – arable area.

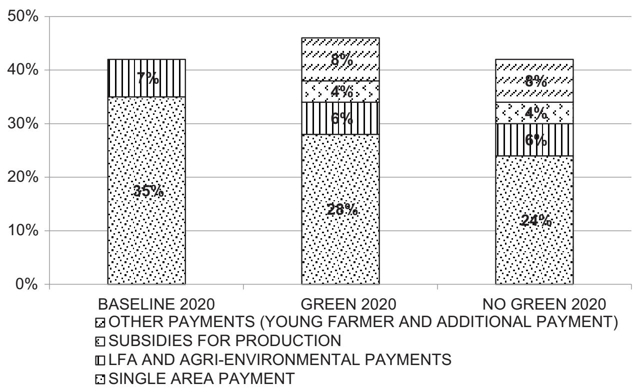


**Figure 2:** Share of subsidies in agricultural income
*Source*: The authors' compilation.

scenario results in a decreased share of subsidies in income. Rejection of adjustment to the 'greening' requirements results in a decrease in the share of subsidies below the level of 2012 mainly in field crop and cattle farms, as well as in the largest farms.

The reform of direct payments and the introduction of additional payments result not only in a change in the share of subsidies in income, but also in a change in the aid structure. Changes in the average share of the various types of payments in agricultural income are shown in Figure 2.

In the GREEN_2020 scenario reduction of the amounts of the Single Area Payment (SAPS), which is the basic component of the CAP financial support for farmers, does not result in a decrease in the average level of aid as the newly introduced subsidies for production offset the reduction. As a result, the average level of aid for farms under the GREEN 2020 scenario is higher than in the BASELINE_2020 scenario.

Reduction of the share of SAPs under the NO_GREEN_2020 scenario results from the introduction of sanctions on non-adapted farms. Limitation of funding for agri-environmental measures and the resulting decrease in agri-environmental payments by 46% has a relatively small impact on the aid structure due to a relatively low level of participation of farms in agri-environmental measures.

It should be noted that the presented structure of payments reflects changes taking place on the average farm, while the share of direct payments in income of larger farms (>30 ha) will be lower by approx. 10 pp. It needs to be emphasized that the presented results do not account for the largest, large-scale farms which are not subject to FADN observations. In the case of the aforementioned farms, the reformed CAP will have a negative impact on their financial performance, mainly due to the EFA requirement and modulation of direct payments.

## 5. Conclusions

Model calculations demonstrate that the final CAP 'greening' will not result in significant adverse changes in the productivity of land and economic performance of farms. Relaxation of the requirements by the European Commission in the final version of the reform means that 'greening' does not significantly affect farm incomes.

A more significant decrease in agricultural income can be seen, however, in certain types of farms (those characterized mainly by monoculture on good soils and those to which the EFA requirement applies). However, in certain types of farms (e.g. cattle ones, fully adapted ones) an increase in income by 2020 can even be noted due to a minor impact of the restrictions being introduced and the increasing level of aid under the newly introduced additional payments.

The introduction of additional payments for farms up to 30 hectares and payments to certain production types (cattle, sheep, goats, soft fruit) increases farm incomes of the smallest farms and on average reduces negative impacts of greening restrictions. The inclusion of leguminous crops and catch crops as EFA equivalents resulted in a further decrease in the percentage of Polish farms which require adjustments to the 'greened' CAP to 20%. By far the largest group of farms classified as non-adapted ones have insufficient EFA. In almost all types of non-adapted farms, the introduction of changes leading to compliance with the 'greening' requirements is for farmers a more favourable alternative than abandoning 30% of the direct payment rate.

In conclusion, the CAP 'greening' will not have a significant impact on the volume of production and incomes in the agricultural sector in Poland. Adverse effects of the regulations may occur in a small number of non-adapted farms. At the same time, it should be noted that, given a high percentage of farms exempt from the 'greening' requirement, or those already adapted, the reform will not contribute to the achievement of environmental effects.

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# A decision support model for the adoption of precision agriculture practices

HP MARÉ[1] and FRIKKIE MARÉ[2]

**ABSTRACT**

The main objective of the study is to investigate the impact of Precision Agriculture practices on the margin and risk of a farming enterprise and the combination of enterprises as a whole-farm business in comparison to Conventional Farming. The procedures that were used to achieve the objective firstly included the scanning of the fields with the Gamma-ray spectrometer for identification of different management zone according to the variation in the physical soil properties and secondly the development of a decision support model namely the SPARÉ Model to investigate the impact of precision agriculture practices on the margin and risk of a farming enterprise and the combination of enterprises as a whole-farm business. The results of the study indicated that precision agriculture can be used strategically to reduce cost and increase productivity, thus increasing profitability.

**KEYWORDS:** Precision Agriculture; Decision Support Model; Management zone identification

## 1. Introduction and background

Precision agriculture (PA) is the use of different available technologies to optimize agriculture productivity by improving management of variability. There is a wide range of technologies that can be utilized to manage site-specific areas within a field. The adoption of these technologies is based on the farm scale, meaning that the level at which it become more cost-effective for a farmer depends on the cost savings for a farm, field or different management zones multiplied by the area (Bootle, 2001).

It is a simple task to calculate an enterprise budget for a certain crop under conventional farming (CF) practices, but it is more challenging to calculate enterprise budgets for different management zones and to calculate and evaluate the most profitable situation for a specific farm or field. This is where the need occurred to develop a model to help plan, analyse and evaluate two different scenarios for a specific farm and/or field. The large amount of variables, such as different crops, management practices, mechanisation technologies, variable rate irrigation (VRI) and variable rate applications (VRA), which must be considered for PA, raised the need for a decision support model (DSM).

A multidisciplinary approach is needed for agricultural scenario planning, analysis and evaluation of profitability and risk. There must be a combined focus on the following aspects namely, agricultural economics, agricultural mechanisation and agronomic principles. A farming operation is based on all above mentioned aspects and the interaction between them, but at the end the ultimate goal is to achieve financial stability and sustainability of natural resources.

The main objective of the study is to investigate the impact of PA practices on the margin and risk of a farming enterprise and the combination of enterprises as a whole-farm business in comparison to CF. The sub objectives are firstly to identifying management zones according to variation in physical soil properties and secondly to develop a DSM to evaluate the impact of PA practices on an individual farm enterprises and the farm business as a whole. The margin and production efficiency is respectively measured with the use of the gross margin (GM) and the operating profit margin (OPM) ratio.

The study is based on an irrigation fields situated on the western side of the Orange River in the Northern Cape, South Africa. The study fields are situated on the 29° S latitude and 24° W longitude, at an altitude of 1024 meters above sea level. The farm produces mainly maize, soybeans and wheat. Currently a CF approach is followed where all the inputs (irrigation, fertilizer and amelioration products) are uniformly applied over the entire field per crop. The input data that is used in the study/model were obtained from harvest monitor data, irrigation scheduling data, physical and chemical soil analysis and historic data obtained from the farmer. The six fields, as presented in Figure 1, that are used in the study covers a total area of 181.95 hectares with an average of 30.32 hectares per field.

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**Figure 1:** Layout of fields used in the study

## 2. Precision agriculture

Precision agriculture (PA) is a broad concept that has various definitions, but it can be described as a catch-all term for techniques, technologies and management strategies that address in-field variability. It focuses on development of integrated information and production systems that manage variability to optimize long-term, site specific and whole-farm productivity and it also minimizes the impact on the environment and natural resources.

Site Specific Management (SSM) is the core concept of precision agriculture. SSM is defined by Lowenberg-DeBoer and Swinton (1997) as the "*electronic monitoring and control applied to data collection, information processing and decision support for the temporal and spatial allocation of inputs for crop production.*" A specific area with its own properties must be locatable to be managed according to a specific manner particular to its requirements to achieve optimum production (Bootle, 2001).

Investment cost is another aspect that must be considered with PA. The total fixed cost of CF is lower than with PA, but with PA the additional benefits are increased production and decreased variable costs (Silva *et al*., 2007). With PA the investment cost in terms of equipment are more expensive, for instance with the adaption of uniform irrigation to variable rate irrigation (VRI) and uniform rate spreaders and planters to variable rate application (VRA).

### Management zone identification

The identification of management zones is another core aspect in PA. Stable management zones can be described as zones that are temporal stable in regards to responsiveness of yield and quality to different treatments. It is thus important to cost effectively identify these zones for differential zone management (Sylvester-Bradley *et al*., 1999).

When these management zones are identified and located, the inputs like plant population, fertilizer, amelioration products, mechanisation, chemical products, irrigation and other variable costs can be manage accordingly. With variable rate application (VRA) the correct amount of resources can be applied on a specific area that will reduce nutrient loss and waste of natural resources like water (Maine, 2006). It will also help to reduce the occurrence of on- and off-site pollution.

Management zones can be identified with the use of different approaches. The methods vary from soil type, soil texture, soil depth, precipitation, a combination of all and spatial variation in crop yield characteristics and Steven *et al*. (1997) suggested the use of multi-year yield maps. Accuracy and cost issues with the above mentioned methods raised the need for a remote sensing method to do in-situ measurements.

A Gamma-ray spectrometer was used in the study to take the measurements for management zone identification. Based on the spectral measurements the sampling locations are selected and soil samples are taken. The spectral measurements at the sampling locations are used to correlate the spectral data to soil properties using the physical soil analysis results of the soil samples. The correlations found in the data are used to create soil property maps that are used to variably apply irrigation to the different management zones with the use of the following concepts.

### Variable rate irrigation

Variable rate irrigation (VRI) is an innovative technology that enables a centre pivot irrigation system to optimize irrigation application (Almas *et al.*, 2003). For the purpose of the study the plant available water (PAW), infiltration rate and crop water usage, shown respectively in Figures 2, 3 and 4, is used to calculate and plan the irrigation scheduling program for the different management zones. The following factors must also be considered namely; the capacity and efficiency of the irrigation system, topography of the field and the scheduling principles for optimum plant production. Sadler *et al.* (2005) found that VRI can reduce the total irrigation water usage with between 8 – 20%.

## 3. Decision support model

Decision support model (DSM) is broadly defined by Finlay (1994) as "*a computer based model supporting the*

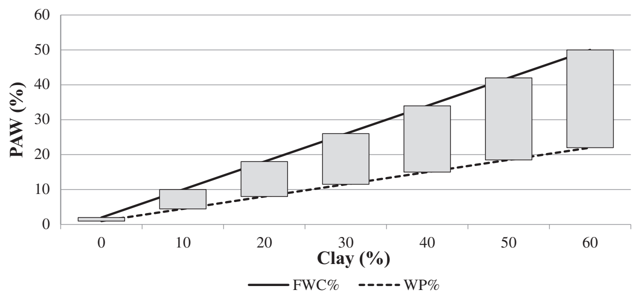


**Figure 2:** Plant available water capacities for different soils by clay content

 

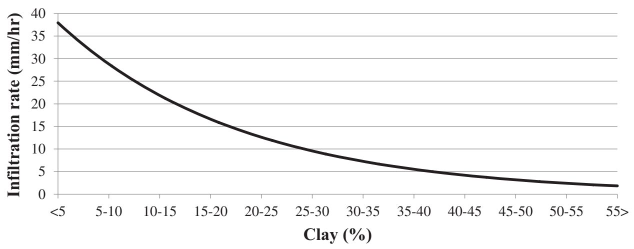


**Figure 3:** Infiltration rate for different soils by clay contents

*decision making process*''. The emphases of the DSM must be on supporting a certain decision in regards to a problem and not necessarily providing an answer. It must enable the farmer to base his/her decision on certain outcomes of different potential courses of action, thus different scenarios. These scenarios can be based on economic, environmental and social factors that may influence a specific choice or outcome.

Precision crop management (PCM) are also important when designing and planning a DSM. PCM can be defined as a multi-objective decision-making process that must incorporate a diversity of data, opinions, preferences and objectives (Jones *et al*., 2000). This will help to incorporate different aspects in one model with the necessary alternatives for possible variability.

## 4. Procedures

### Management zone identification

Figure 5 shows the correlations according to the Count Rate (Bq/kg) for the soil properties from the measurements obtain by the Gamma-ray spectrometer. The regression values that were respectively obtained for clay, silt and sand was $R^2 = 0.97$, $R^2 = 0.81$ and $R^2 = 0.92$. The formulas obtained from the correlations are then used in a PAW model to extrapolate the specific property values to all the Gamma-ray spectrometer readings.

The plant available water (PAW) in millimetre is calculated as:

$$PAW = FWC - WP \tag{1}$$

where

FWC Field water capacity in millimetre as calculated

WP Wilting point in millimetre as calculated

After the calculation, interpolation and mapping of the PAW to the specific field boundaries with the use of Spatial Management Systems (SMS) software, the management zones for SSM can be defined. The physical and chemical properties of the soil can then be classified into the specific management zones. After identification of the management zones the variable rate irrigation

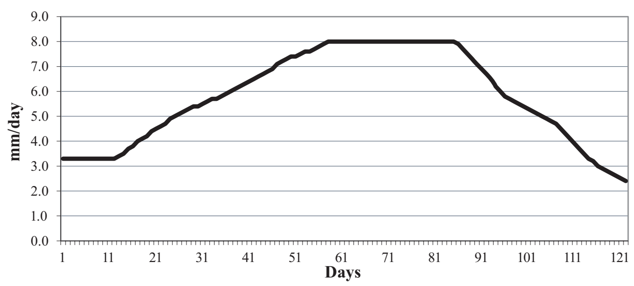


**Figure 4:** Daily crop water usage demand of maize

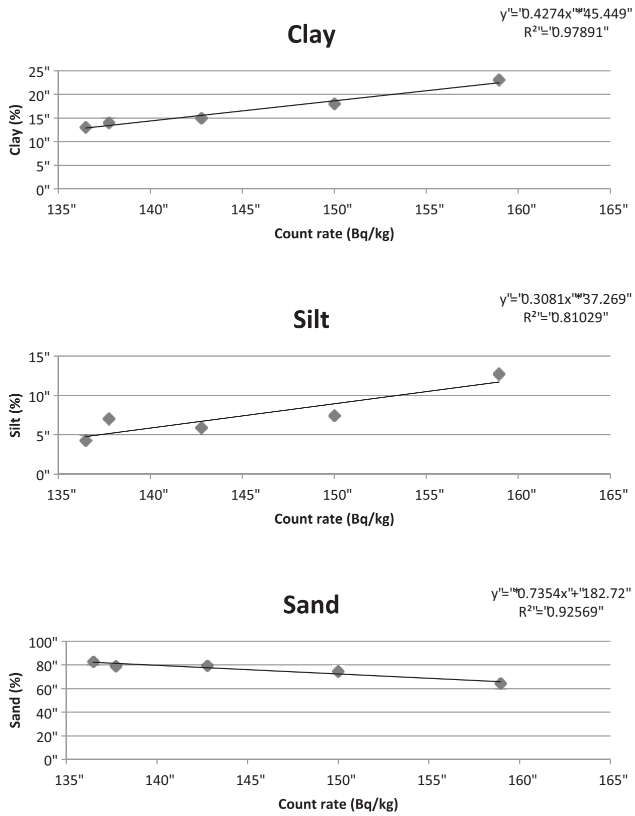


**Figure 5:** Regression curves showing the correlation between the physical soil properties and Gamma-ray spectrometer measurements

(VRI) and variable rate application (VRA) of fertilizer and amelioration products can be planned in accordance to the crop yield potential of the specific management zone.

### Decision support model

The SPARÉ Model (Scenario Planning, Analysis and Risk Evaluation) is designed to plan and evaluate two different scenarios under irrigation and/or dry land conditions with the use of multiple enterprise budgets per management zone and different crops per annual production cycle. There are certain designated sheets for the different production inputs for instance; fertilizer, lime and gypsum, mechanization costs, chemical products and water and electricity. These inputs can be changed per region, farm, season, etc. and the same cost is used for calculations in both scenarios.

The first step of the model is to use the different management zone areas and plan the farming operation accordingly. The initial farm planning consists of rotational crop planning per management zone per season for irrigation and/or dry land according to a percentage of available area. After the initial planning is completed, individual crop enterprise planning must be done per management zone. This planning proses consist of the following variables per zone namely; seeding, fertilizer, ameliorants, mechanization, water demand and management, chemical products and other costs. The following variable costs are taken into consideration to calculate and plan the whole farm business and each crop - and management zone enterprise individually. The variable costs consist of seed, fertilizer, ameliorants,

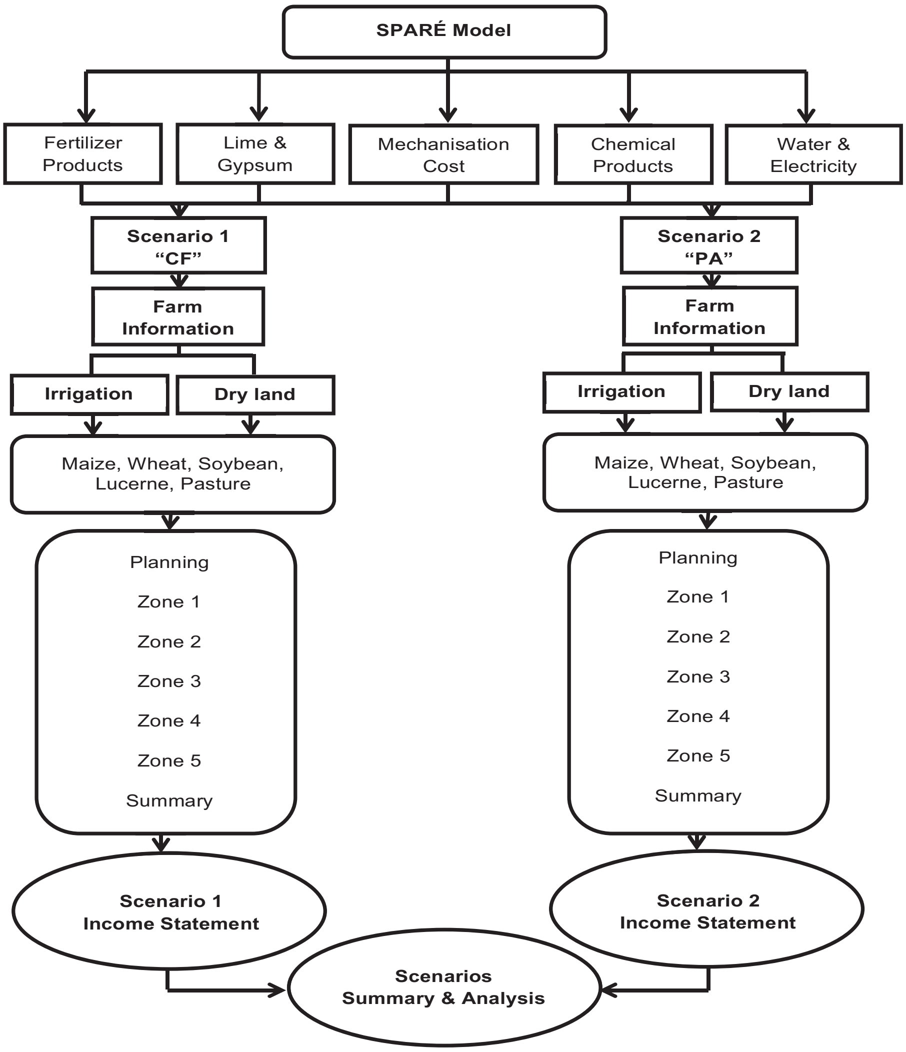


**Figure 6:** Schematic representation of the SPARÉ Model

mechanization, herbicides, pesticides, insurance, irrigation, transport, marketing, other variable costs and interest on operating capital. All these cost is taken into account to calculate the impact on each enterprise in accordance to the whole-farm operation.

The model's structure are described in Figure 6 which shows the overview of the model as a whole from farm information, management zone planning, enterprise planning, and enterprise budgets to the farm income summary, evaluation and analysis.

The values that are used in the model are shown in Table 1 and margin-, income-, cost- and analytical values are included[3]. All calculations start from management zone level, then enterprises level to whole-farm level. The gross margin (GM) of the scenario (SC) is the final answer in regards to profitability and is calculated as:

$$GM_{SC} = GI_{SC} - TVC_{SC} \tag{2}$$

where
GI Gross income (R)
TVC Total variable cost (R)

The total income of all the management zones give the sum of the specific enterprise and the total of the enterprises give the sum for the specific scenario. The gross income (GI) of a scenario (SC) is calculated as:

$$GI_{SC} = GI_{E(Ia + Ib + Ic + Id + Da + Db + Dc + Dd)} \tag{3}$$

where
$_E$ Enterprise
$_{I\#}$ Irrigation enterprise where # represents enterprise (a – d)
$_{D\#}$ Dry land enterprise where # represents enterprise (a – d)

The cost calculations consists of variable cost and it is the part of the total cost component that could vary within the framework of a specific production structure as the size of the enterprise varies and/or the intensity of the production per unit changes. The total variable cost (TVC) of a scenario (SC) is calculated as:

$$TVC_{SC} = TVC_{E(Ia + Ib + Ic + Id + Da + Db + Dc + Dd)} \tag{4}$$

Financial analysis pertains not only to income and expenditure, but also to the ability to meet financial liabilities, carry risk and strategically utilise available capital. The breakeven price and yield is simple calculations that can be used to calculate the minimum price and yield that must be achieved for a specific management zone or enterprise to be profitable. The operating profit margin ratio is used to measure the operating efficiency of a farm business and it is

[3] All calculations and formulas are available on request from author.

 

usually written in percentage. The operating profit margin (OPM) for the enterprise (E) is calculated as:

$$OPM = (GM_E / GI_E)\% \quad (5)$$

## 5. Results

### Management zones

The PAW (in millimetres) of the fields is shown in Figure 7. The field's clay percentages vary between 5% and 30% and the PAW varies between 35 millimetres to above 50 millimetres. The infiltration rate are directly correlated with the clay percentage and it varies between 25 mm $hr^{-1}$ to as low as 8 mm $hr^{-1}$. From the variation in spatial PAW data, five management zones in pie slice-shaped sectors are identified. The management zones (sectors) differ in sacraments of five from below 35 millimetres to above 50 millimetres. The zones are respectively 13.9, 47.8, 47.1, 57.3 and 15.6 hectares. These management zones are used in the decision support model for the PA calculations.

### Decision support model

Figure 8 presents the total income from different enterprises for PA and CF. It is evident from Figure 8 that the total income generated with PA is more than with CF for all the enterprises. The average increase in income from PA for all the enterprises is 9.6%. The individual income of maize, wheat and soybean is respectively 8%, 13% and 8%. The reason for the higher income for wheat is because no sampling or amelioration has been done during the wheat season.

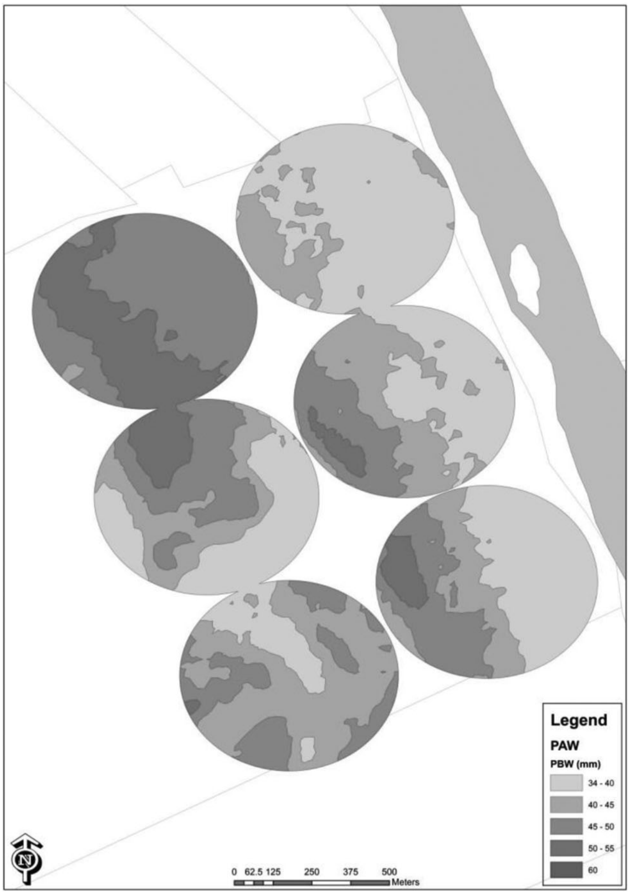


Figure 7: Plant available water map of the study fields


**Figure 8:** Total income for different enterprises according to CF and PA

In the model all the inputs as shown in Table 1 is used for the calculation of the TVC of the two scenarios. The difference in TVC of PA to CF can be seen in Figure 9, with only the inputs that varies between PA and CF is shown in the figure.

From Figure 9 it is evident that the largest difference in cost is with total other variable cost (TOVC). The TOVC of PA is 282.8% higher than CF, because of grid samples that were taken, the scanning of the soil for physical soil variations, the use of a spreader contractor for application of amelioration products and the cost involved for adapting the irrigation system to VRI. Although the higher cost of TOVC, it only represents 3% of the TVC of all enterprises.

It must be taken into account that it is only necessary to take grid samples every three years for VRA purposes, because the chemical soil properties will only change significantly over that period of time due to management practices. This will lead to a lower TOVC in the seasons that follow. In regards to the management zone identification the cost is once-off, because the physical soil properties does not change over a short period of time. The cost of adaption to VRI technologies is calculated per season per hectare over a period of 5 years. It is found that the useful life of these technologies is between 5 to 10 years (Bootle, 2001).

According to the total amelioration product cost a 31.3% saving is made with gypsum and 0.7% saving in regards to fertilizer for PA. Although only 0.7% less amelioration fertilizer is used, it must be taken into account that the application of the fertilizer is site-specific in accordance to the inefficiency of the soil's chemical properties and that leads to higher efficiency of applied product. When looking at the amelioration fertilizer of the individual enterprises, the cost of maize is 1.2% higher and soybeans 2.5% lower. This only shows that a saving is not necessarily made, but the product is more effectively applied.

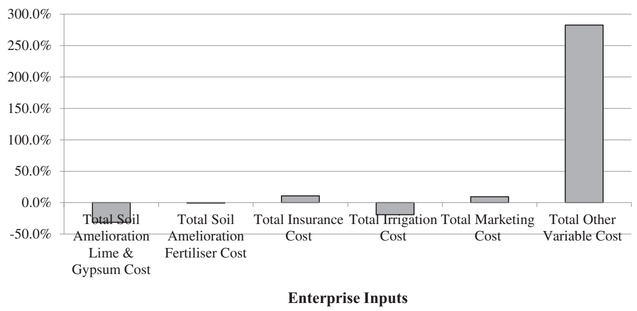


**Figure 9:** Percentage variation between input costs of PA and CF

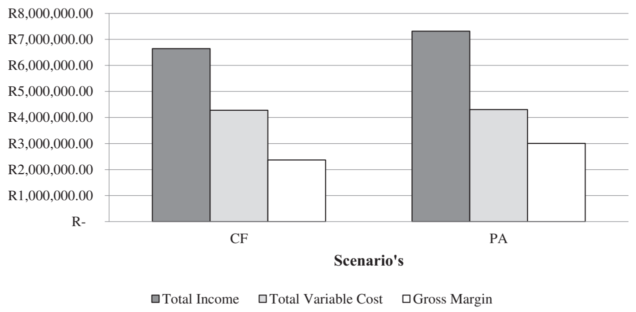


**Figure 10:** Summary of total income, total variable cost and gross margin of CF and PA

The total cost of irrigation is 19.2% lower with PA than CF, the saving occurred from the efficient application of irrigation water. Although the same amount of irrigation is applied over the field according to the crop water demand, the different management zones is managed in accordance to each zones measured properties namely, PAW and infiltration rate. A further benefit is that less nutrient losses occurs due to leaching and that leads to lower on- and off-site pollution.

### Analysis and evaluation

In Figure 10 the Total Income, Total Variable Cost and Gross Margin are shown for CF and PA respectively. For PA the TI is 10% higher and the TVC is 0.7% higher than compared to CF, while the GM is 26.9% higher for PA than for CF. When looking at the OPM it is 36% and 41% respectively for CF and PA. It is thus 5% higher in the case of PA, making PA more profitable than CF. It also means that PA has a better return on investment (ROI) than CF for each Rand spend.

Comparing the individual enterprises according to CF and PA practices it is evident that PA is more profitable than CF. The GM for maize, wheat and soybeans are respectively 22.3%, 27% and 36.2% higher for PA than for CF. The OPM of CF and PA for maize is 32% and 37% respectively, for wheat it is 48% and 54% respectively and for soybeans it is 20% and 27% respectively.

From all these figures it is evident that PA practices is more profitable than CF with the correct ratio of in-field variation. It can also be seen that from all the enterprises soybeans is the most profitable crop, but wheat has the highest OPM.

## 6. Conclusion

The objectives of the study were twofold. The main objective of the study was to investigate the impact of PA practices on the margin and risk of a farming enterprise and the combination of enterprises as a whole-farm business in comparison to CF. The sub objectives were firstly to identifying management zones according to variation in physical soil properties and secondly to develop a DSM to evaluate the impact of PA practices on an individual farm enterprises and the farm business as a whole. The margin and production efficiency was respectively measured with the use of gross margin (GM) and operating profit margin ratio (OPM).

The procedures that were used in the study included the scanning of the fields with the Gamma-ray spectrometer for identification of different management zone according to the variation in the physical soil properties. Secondly a DSM was designed namely the SPARÉ Model to investigate the impact of PA practices on the margin and risk of a farming enterprise and the combination of enterprises as a whole-farm business.

The results of the study indicated that PA can be used strategically to reduce cost and increase productivity, thus increasing profitability. In the study the total variable cost and total income of PA is respectively 0.7% less and 10% higher than with CF. There are an increase of 26.9% in gross margin for PA against CF. When looking at the operating profit margin ratio (OPM) it is 36% and 41% respectively for CF and PA. It is thus 5% higher in the case of PA, making PA more profitable than CF. It also reduces the impact of agriculture on the environment and natural resources.

It is found that the feasibility of PA practices depends on field variation, crop value, economics of scale and the useful life of the equipment. According to Maine (2002) "*PA has the potential to enhance profitability on South African soils, which are characterized by great variability in depth and fertility within given fields.*" Variable rate irrigation (VRI) will also become more important in the future to protect the scares water resources in South Africa and the world. The measuring of efficiency in agriculture will become more important and it can be defined as the relationship between output and input calculated as a ratio.

## About the authors

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# Investing in a Policy Innovation World

FORBES ELWORTHY[1]

## Overview

It is a remarkable thing that over one quarter of world government bonds are now yielding negative interest rates e.g. French 5 year government bonds ("OAT's" - Obligations Assimilables du Trésor) are costing investors 0.17% each year for the privilege of owning them.

This viewpoint reviews recent policy innovations including negative rates. I then categorise the macroeconomic policies of countries into four types:

1. 'Good Housekeeping' (New Zealand, Switzerland);
2. 'Just QE' (US, UK, Germany),
3. 'Spend and Sterilise' (Italy, France, Japan - until 2015),
4. 'Print and Spend' (China, Turkey, Hungary and Japan - post 2015),

as per the following matrix (Figure 2), developed further in this Viewpoint. I then argue that Japan, the US and the UK are shifting toward policies of direct stimulation of consumption using printed money i.e. 'Print and Spend'. I predict this policy shift will eventually spark inflation in the US and UK. If not in Japan. After analysing possible impacts and risks of these policy trends I conclude with a summary of where I am currently investing our family's capital.

## A Short History Of Policy Innovation

Long Term Capital Management defaulted on its debts in 1998 at a time the US economy was doing fine - so did not need lower interest rates. However, even so, to protect the financial markets from contagion, Alan Greenspan's Federal Reserve lowered interest rates to low levels. A period of financial markets repair followed, which turned into an equities boom, which in turn collapsed in 2000. After which interest rates were again briefly lowered, to around 1%.

A period of 'pump priming' had begun. Each time markets swooned they were revived by monetary action. This support became known as the Greenspan Put. It became a good idea to 'buy the dips' on any market weakness. Those of us trading securities came to expect monetary loosening each time the markets fell. Naturally enough an even bigger market boom emerged. This time supported by leverage. That boom collapsed in 2008 and 2009.

The ensuing 'Great Recession' was revived largely by US deficit spending. However, after 2010 political tolerance for deficits receded and a new Policy Innovation emerged. This was Quantitative Easing – the non-sterilised i.e. 'printed' purchase of financial assets by central banks. Like the earlier post-1998 Policy Innovations QE was primarily employed to reflate asset prices and boost financial markets. Which were deemed to be not shifting money around fast enough (the velocity of money had collapsed), hence their support during the downturns of 1998, 2000-2003 and 2008-now. 2015 saw a further Policy Innovation - negative interest rates. These have been so far confined to Japan and Europe but may be introduced to the US dollar if deflation and/ or financial market volatility returns to the US in the future.

## What Have These Policy Innovations Got In Common?

Some common denominators of the above 18 years of Policy Innovations are:

- An asymmetric 'policy ratchet' lifts asset markets by actively supporting falling markets. Yet it does not discourage rising prices in boom periods.
- Fiscal and deregulatory measures to support growth seen in the 1970's and 1980's have been largely replaced by monetary interventions. Governments have come to see monetary support of the economy as the main transmission mechanism for macro policy.
- Central Bank balance sheets (i.e. 'core money') are growing as they are used to support markets. Further these asset purchases are increasingly non-sterilised, i.e. financed by printed money.
- As earlier Policies become ineffective new Policies are introduced.
- Few of the Policy makers (outside of Switzerland and Germany – rare countries with households with net savings) seek to preserve the value of currencies. Almost all of the Policies – and here the Germans have fallen into line with the rest of Europe - subordinate the role of money from a store of value to become 'activist policy variable of choice'.
- In a related point governments compete to help their export industries by lowering the value of their currencies. Switzerland has been the typical example: higher interest rates than in Europe were acting like a magnet for its neighbours' savers, thus overvaluing the Swiss Franc and hurting the Swiss economy. The SNB then had to weaken the Swiss Franc to keep the Swiss economy healthy.
- There is a distributional bias in the Policies. Leveraged people and organisations (mortgage borrowers, leveraged corporates, banks, hedge funds) are supported and repeatedly 'rescued' by policies supporting credit markets. Yet investors, especially those saving into

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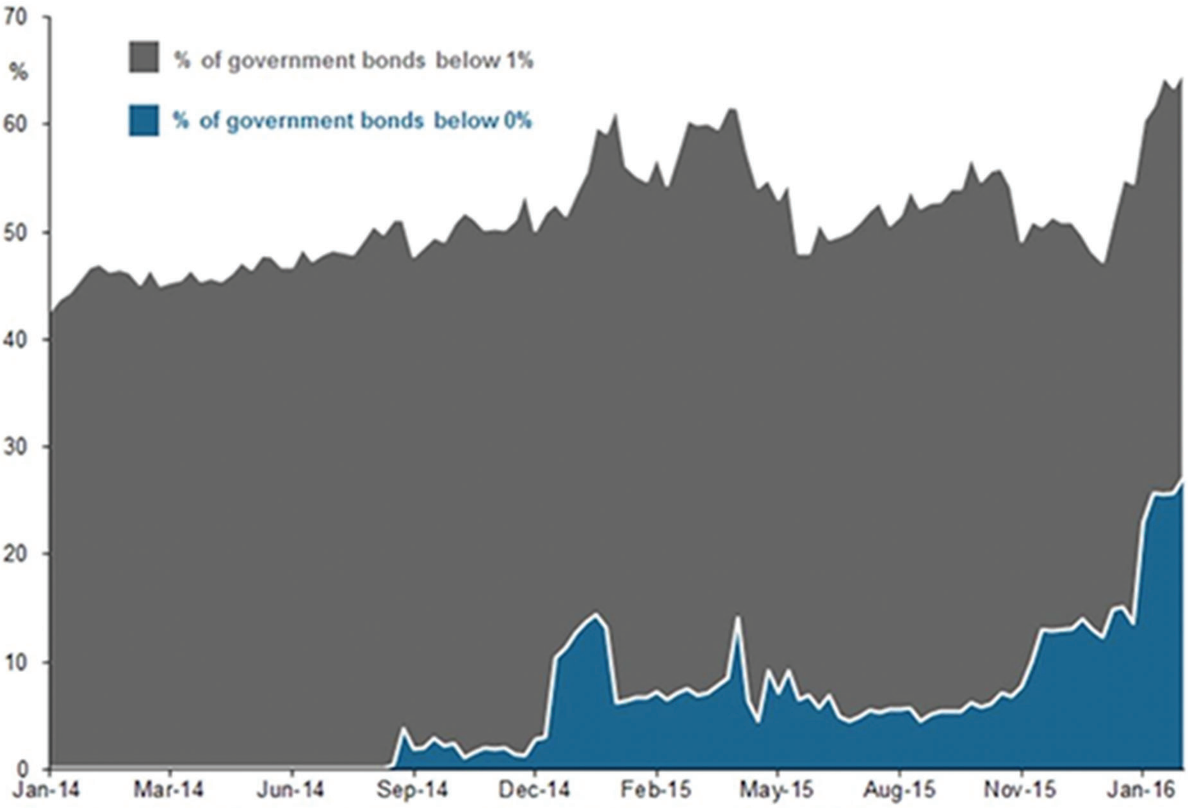


**Figure 1:** Yield on Global Government Bonds
*Source*: Bloomberg, BofA/ML, JP Morgan AM. Index shown in the BofA/ML Global Government Bond index. Data as of 25 Feb 2016. Cited in DSG Asia

| | *Fiscal Balance* | *Fiscal Deficit* |
|---|---|---|
| *Money-printing* | "Just QE" | "Print & Spend" |
| *Sterilisation of expenditures* | "Good Housekeepers" | "Spend but Sterilise" |

**Figure 2:** Macroeconomic Policies

bank accounts and bonds, will see their interest returns undermined by the interventions[2].

## Why Are These Policies So Popular?

Outside of those rare countries with net positive household monetary savings these policies have a lot of appeal to most of the population – at least to the part owning houses and other assets – and to politicians. They are also supported by most professional economists. Some reasons include:

- Contrary to what a lot of us learned when studying economics (where we were taught that changes in nominal balances should not impact the real economy), it has become clear that injections of printed money into economies can, at least in the short term, boost real GDP. E.g. China's government credit support has boosted Chinese GDP while QE in the US and UK has boosted property prices, wealth and spending.
- The policies appear 'victimless'. In a world with vigorous global competition in many industries and hence widespread deflation the stimulation offers higher GDP but inflation remains low. Some are better off and few are worse off. Even rentiers (e.g. people saving into pension funds and insurance companies that buy mostly bonds) are not aware of their predicament as the fall in interest rates has been masked, thus far, by accounting increases in 'returns' as bond prices rose.
- The economics profession is the main source of the Policy Innovations. These central bankers and

[2] This effect has been masked by the fact bond prices have risen making savers feel they are better off. The eventual 'euthanasia of the rentier', dear to Keynes (discussed in my Commentary of May 2015) will become more clear in coming years now that there will be no further capital gains to be had on bonds i.e. now that interest rates are at, below or approaching the zero bound.

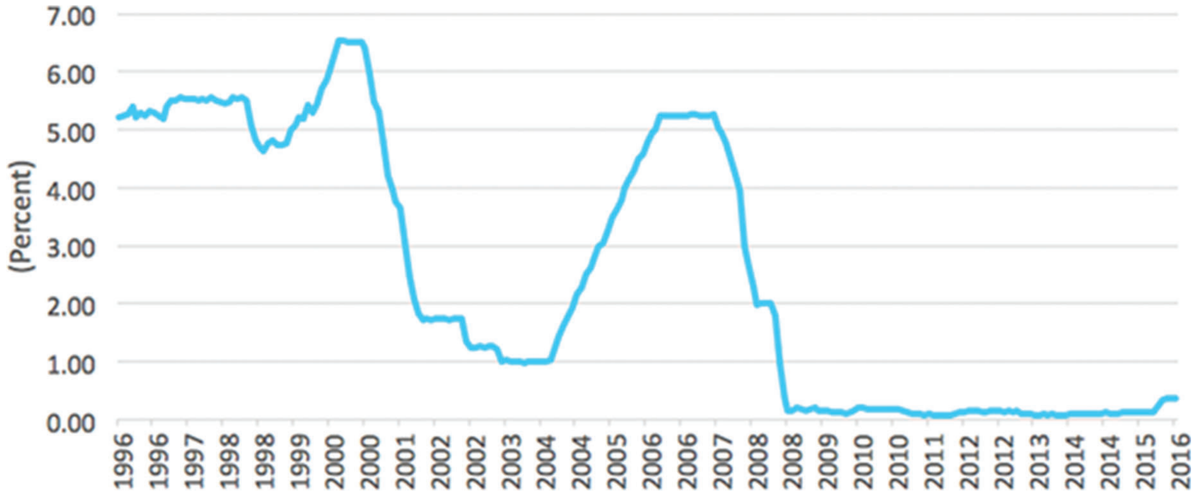


**Figure 3:** Effective Federal Funds Rate
*Source*: Federal Reserve Bank of St.Louis

advisors judge success (and are judged and promoted in their jobs) by their ability to maintain short term GDP growth. Economists at the Bundesbank and BIS who express concerns about long term stability and also unintended consequences of the policies (such as zombification of large parts of the economy) have been side-lined. A resurgent Keynesian/Monetarist activist mainstream is firmly in power in economics policy circles.

## What Is Likely To Happen Next?

Given their apparent benefits, and also that populations have now got used to these measures being implemented without apparent disaster, it seems likely:

- Governments and Central Banks will continue to Innovate Policy.
- Bold new Innovations will be adopted each time GDP slows.
- The new policy measures will increasingly rely on printed money rather than taxes or government borrowing.

Recent discussions in Policy Innovation circles suggest that, when the next recession threatens, three new Policy directions are possible:

- The first is unfunded government 'fiscal' investment in social and infrastructure programmes. Here, as with QE, it is proposed governments will announce the money will not be recovered with taxes, but instead be irreversibly printed. This is to counter the risk that the populations worry that taxes will be raised to pay for the spending and cut back on their own expenditure, negating the boost to demand.
- The second is the 'helicopter drops' (basically taxes in reverse) that Milton Friedman prescribed as a cure for deflation (and for which Ben Benanke has recently presented a 'how-to guide'[3]). This pure fiscal stimulus will transfer printed money directly into citizens' bank accounts. In the Financial Times last week an economist from JP Morgan argued this was a better route forward than deficit spending, as would avoid Governments developing bad spending disciplines. Some disagreed nevertheless. Goldman's economist countered she would prefer to see fiscal expansion as helicopter drops will create nervousness.
- A third possible Policy direction is capital controls. Where investors' rights to transfer capital offshore are restricted (as China and India do now). These Polices would again aim to force money out of passive savings (in this case offshore) and into domestic investment and consumption.
- Fourth and most dramatic would be limits on convertibility of various forms of saving and money – otherwise known as currency reform. At its mild end this might involve abolition of large denomination bank notes (to restrict paper savings in negative interest rate environments). A further step could be abolition of non-electronic money (all bank notes and coins). More dramatic still would be bans on or taxation of scarce assets that act as crypto-currencies (Roosevelt's confiscation and forced conversion into paper money of US citizens' gold in 1934 an example). At its most dramatic, currency reform might involve mandatory re-pricing of assets and liabilities. A biblical economy-wide debt jubilee. This would be an extreme form of confiscating value from savers and gifting it to credit borrowers.

## How Likely Are These Further Policy Innovations?

Politicians, the media and the citizenry of the major economies have become accustomed to government action to boost the economy, and will call loudly for medicine if GDP begins to falter; they expect intervention to solve the problem. Few (other than the 'This Time Is Different' Harvard economists Reinhart and Rogoff) are old enough to recall disastrous denouements to previous periods of government economic activism[4].

Economists are aware Policies become 'stale' after a period. Households, eager to save against an uncertain future (and indeed avoid the depredations of Policy

[3] *What tools does the Fed have left? Part 3: Helicopter money*, Ben Bernanke, http://www.brookings.edu/blogs/ben-bernanke/posts/2016/04/11-helicopter-money

[4] I saw it in New Zealand in the 1980s – when we came off our government supported investment binge of the 1970s – and suffered a 15-year economic hangover as we built integrity back into our economic system. However, evaluating the quality of the Policies is not the point of this Commentary. My aim is to predict what will happen, not what should happen.

 

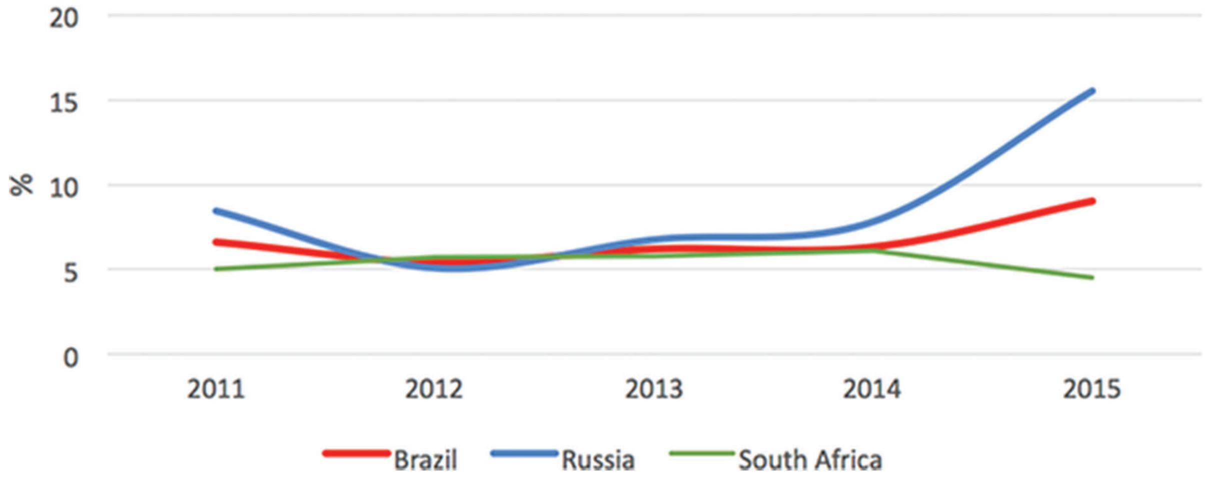


**Figure 4:** Inflation Rates (annual change of CPI)
*Source*: OECD

Innovation), adjust their behaviour and find new ways of preserving wealth. So Policy Innovators, always eager to push capital out of passive saving into aggregate demand, need to find new ways of doing this.

Given the above political and institutional backdrop it seems likely the next time a recession beckons that some mixture of Deficit Spending and Helicopter Money will be employed in the developed countries. (I make guesses in which countries in the next section). Capital Controls and Currency Reform currently appear, to me, more distant prospects in OECD countries. But they will be worth watching out for.

## What's A Poor Investor To Do?

I have long predicted that, in the looming battle with deflation, inflation would eventually win. My argument has been based on the 'ratchet' in government policy in favour of economic expansion, even at the cost of monetary discipline. I urged purchase of real assets, which should benefit from the inflationary bias. So far I have been wrong about inflation – in almost all developed countries now running below central bank target rates in a globalised economy with vigorous supply competition in many sectors. Like Jeremy Grantham[5]. I hereby eat humble pie and acknowledge that my predictions of inflation in goods and services markets have not (yet) been fulfilled.

I was, however, right about real assets - equities and property, including farmland - which have risen in value since their lows of 2009 driven by falls in interest rates, lower risk premia and some (if modest) recovery in real GDP.

## Predictions For The Next 8 Years

Undaunted I continue to believe that we are right to expect inflation, eventually. Further I believe those who are brave and who continue to invest in the real economy, to invest in growing businesses, and in productivity and innovation will be rewarded. They will be helped by further Policy Innovations that are (going to) systematically confiscate value from passive nominal savers and use this to boost consumption and investment.

I believe those who put their savings into passive, nominal investments are going to be on the wrong side of a history that is seeing governments systematically suborning money as a store of value.

## But What About Japan?

Of course my recommendation would have fared poorly in Japan during the past 27 years – where apparently the right thing to do was to sell real assets and to hold capital in e.g. government bonds. However, Japan is a different place. Japan has/had very high rates of saving. In a country with falling asset prices and with citizens saving as much as 30% of their income it takes many years of Policy Innovation to kill off that deflationary weight on consumption, and to boost demand and GDP growth.

The US and Europe do not have as large a savings buffer as Japan. They are likely to arrive within a few years at a place Japan is only just arriving after many years of 'medicine'. Further Japanese policy thinkers (for a good illustration see Richard Koo's *The Holy Grail of Macroeconomics: Lessons from Japan's Great Recession*) relied entirely on sterilised i.e. bond market funded deficit spending to boost the economy until very recently. It is only in the past 3 years that Japan has lost its fear of inflation, and begun to print money and debase the currency via QE, ZIRP, NIRP & monetisation of the Yen in the face of government debts of 300% of GDP.

In the East, just as in the West, debts that cannot be repaid will not be repaid, and will be defaulted on, either via an outright restructure (like Greece) or via monetary debasement and inflation (far more likely in the case of sovereign currency issuers like Japan, UK, US).

## Categorising Policy Innovation

In Figure 2 Policies that fund (i.e. 'sterilise') government and central bank expenditures (via taxes, bond issuance or sale of FX reserves) are on the bottom row and those that see governments pay for capital, fiscal or FX interventions with printed money are on the top row.

[5] GMO 1Q 20016 Letter, *Always Cry Over Spilt Milk (An Admission of a Past Mistake on Resources)*, Jeremy Grantham, https://www.gmo.com/docs/default-source/public-commentary/gmo-quarterly-letter.pdf

Policies of fiscal balance are shown on the left and of fiscal deficit on the right.

As noted in the introduction 'Good Housekeepers' include Switzerland and New Zealand. These do not run fiscal deficits or seek to sterilise government or central bank investment with government bond issuance. 'Just QE' countries include the US, part of Europe and the UK. These monetise purchases of financial assets, but have maintained relative fiscal balance. 'Just QE' Polices do not cause goods and services inflation - only asset market inflation. In fact I have argued in an earlier Commentary these policies may be deflationary, as they drive investment in excess production capacity.

In the bottom right cell 'Spend but Sterilise' countries such as Japan pre-2015 (and the Euro-zone fiscal deficit countries such as Italy and France) run large fiscal deficits but sterilise these via issuance of government bonds, so that the core money supply does not increase. These Polices are, like 'Just QE', non-inflationary. They do not increase the amount of dollars chasing each good or service. Stimulation from the government spending more than it taxes is precisely off-set by bond issuance.

Finally 'Print and Spend' countries currently include, Brazil, South Africa and Russia. These countries run large official and unofficial fiscal deficits and fail to 'soak up' the extra money supply from the expenditures by issuing bonds. It should be no surprise that all of them are experiencing inflation in goods, service and wage prices.

## The Next Phase Will Be Inflationary

I argued above that the common denominator of current policy trends is debasement of money by governments in pursuit of GDP growth objectives. And then observed that, at least in developed countries, the polices were largely confined to the spending of extra currency in asset markets, thereby lifting asset but not goods and service prices. I expect this to change now that asset price rises have reached their natural limit (now that interest rates along the yield curve are approaching zero). In particular I expect a shift in Policy up and to the right on the earlier table (i.e. no more sterilisation or fiscal responsibility). Hence earlier 'Spend but Sterilise' countries such as Japan have recently shifted to 'Print and Spend' mode as they actively seek inflation. In the West 'Just QE' countries are beginning to talk about Fiscal and Helicopter interventions. If adopted these would shift them rightwards to 'Print and Spend'.

Direct monetary support to demand for goods and services while not increasing supply is likely, absent Policy Failure, to cause inflation to finally return to these economies. Financial traders often remind each other 'don't fight the Fed'. The Fed (and other central banks) have been signalling for a number of years they want to lift inflation rates. It may pay to listen.

## What are the risks of these policy trends?

There is a risk of Policy Failure of 'Print and Spend' policies. Rises in interest rates and/or falls in financial markets that occur as inflation rises may cause citizens to lift savings rates and/or engage in capital flight – channelling the printed money into other places and not into demand. In which case either continued deflation or inflation with low growth i.e. Stagflation would be the likely result. Countries like Japan with risk averse (high savings) populations are particularly at risk of Policy Failure. Japanese citizens, discerning the government is attempting to default on their JGB savings via inflation, may prudently try to restore their position by saving the printed money.

Policy failure is less likely in countries which do not allow interest rates to rise until well after aggregate demand and inflation have begun to rise. The US and UK may be already on this pathway. Inflation expectations are higher in both countries. Indeed, core inflation is currently running at 2% in the US and 1.5% in UK.

The second risk of 'Print and Spend' is that it does cause inflation, and that this then lifts interest rates, which in turn causes crashes in financialised asset prices previously supported by low interest rate and QE policies. In other words, after many years of asset prices rising faster than goods & service prices the pendulum might now swing the other way. Goods, services and wage prices may rise while financial assets fall. Given the importance of equity and credit markets for private sector jobs any political joy from this rebalancing might be short lived (if unemployment rises). It would be likely to lead to a reduction in investment and therefore stagflation.

Because policy makers are keenly aware of the above risks, I predict they will carefully manage policy interest rates at levels below (i.e. lagging) inflation for a number of years. I.e. I expect a period of sustained negative real interest rates (indeed we are already there with 2% inflation in the US and 0.5% policy rates). It logically follows that this 'lag' in normalising interest rates is both very likely and also probably the biggest risk of all. If policy makers (as always favouring borrowers over lenders) allow inflation to run for quite a few years before raising rates, this could create volatile economic conditions, especially if inflation gets out of control (and expresses itself in various forms of boom and bust).

## What Assets Am I Buying In This Environment?

I split the investment world into four major asset types based on the degree to which they are financially leveraged and how much supply elasticity (ability to grow capacity) the assets are. For example, Old world assets such as Gold has very little financial leverage and supply remains constrained no matter the demand:

For reasons set out above I am currently avoiding assets in the bottom left of this table: 'Financialised Capital'. Any rises in inflation will mean that interest rates will eventually need to rise. Expectations of this may cause banks, insurers, hedge funds etc. to suffer quite badly. I expect the share of GDP devoted to financial activities may shrink in the face of inflation and rising interest rates.

'Big Business' (bottom right) should do well if growth returns along with inflation. For this reason, high quality (non-financial) stocks and private equity should be represented in portfolios. However, as noted there is a risk of Stagflation. Hopefully this only a minority chance, but Stagflation has traditionally challenged corporate profitability and valuations. This risk makes me cautious

 

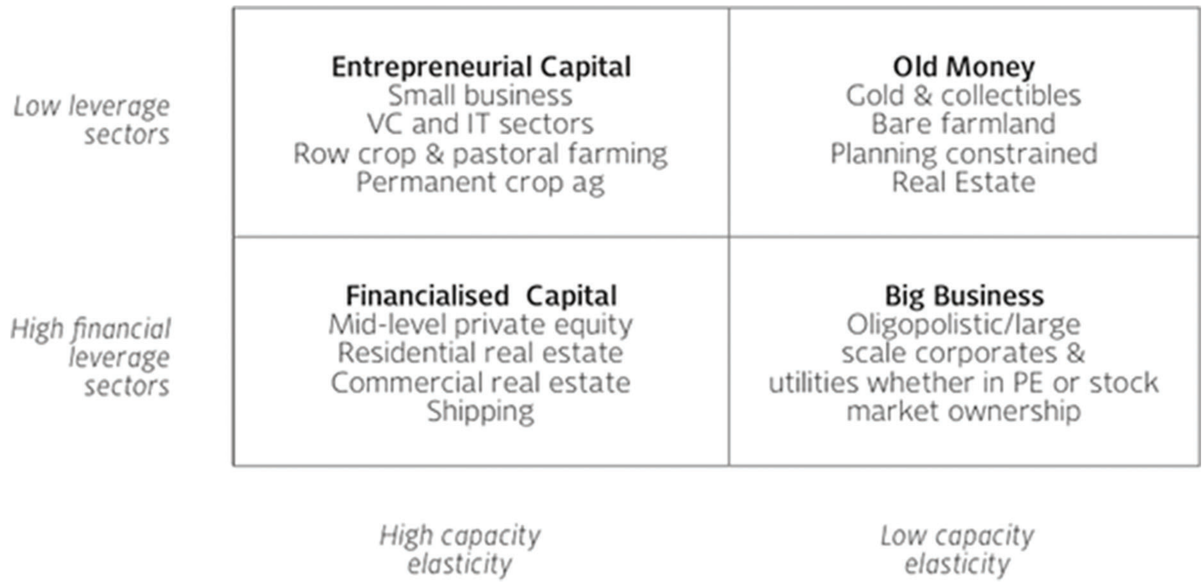


**Figure 5:** Major asset types

about corporate equity, although I do maintain some in our portfolio.

So much for the leveraged asset classes on the bottom row of the matrix. I now turn to typically unleveraged assets along the top row.

Entrepreneurial companies (top left), especially growth companies are a great way of riding technological change to create investment value irrespective of market conditions. However, there are risks here too and this is a difficult asset class to gain access to (many tech companies once listed are already mature, and over their growth phase). In order to 'do this ourselves' I am currently investing capital into our own 'Map of Agriculture' farm information and communication company. And also our Craigmore Sustainables investment management business, which is now growing steadily – with over NZ$500m of farming assets under management.

However, I must admit I am becoming more and more drawn, in an uncertain world, to the 'Old Money' scarce (and inflation-proof) assets (top right), particularly farmland, but also some gold (accepting risks to gold in a phase of currency reform). These types of assets have zero or low physical and economic depreciation. Consequently, they have low yields and do not support much leverage, so are unlikely to be 'sold off' in a deleveraging. Being scarce, there is a sense in which Old Money assets act as real currencies as well as investments. Hence they traditionally do well in times of inflation.

Farmland prices in NZ, US and UK are currently falling after three years of good harvests and poor commodity prices. This is creating opportunities for Craigmore in our favoured NZ and UK target regions. Craigmore is currently deploying two new NZ farming partnerships. New projects include senior unsecured farm debt and UK farm real estate projects.

## About the authors

**Craigmore Farming** is a New Zealand farmland investment manager founded by Forbes Elworthy and Mark Cox in 2009. The Group now manages over 11,000 hectares of NZ sheep, beef, dairy and horticultural farmland valued at NZD 500m.

**Forbes** was brought up on Craigmore Station in the South Island of New Zealand and worked as a shepherd in the early part of his career. He then trained in Agricultural Economics at Lincoln University in New Zealand where he was student president in 1984. He went to Oxford as a Rhodes Scholar in 1985. After some time at Goldman Sachs he completed an MBA at Harvard Business School in 1992. Forbes worked as a credit trader at Merrill Lynch from 1992 to 1999 where he headed a convertibles trading desk. He then led financial information publisher Credit Market Analysis which was acquired by Chicago Mercantile Exchange. Forbes returned full time to farming in 2005 to live on and manage Craigmore Station – a sheep, beef and deer property farmed by the Elworthy family since 1864. He now spends his time managing Craigmore and an agricultural research and analytics business Map of Agriculture (formerly Craigmore Research).

# REFEREED ARTICLE

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# Corn and Soybeans in the Central Black Soil Region of Russia: A fundamental shift in cropping patterns ahead of us?

SERGEY CHETVERTAKOV[1,2] and YELTO ZIMMER[1]

**ABSTRACT**
Recent statistics show an increase in corn and soy production in the Voronezh region, one of Russia's most important agricultural regions. This paper analyses the background of and the reasons for this development. To achieve this goal, the authors used data from *agri benchmark* typical farms and focus group discussions with farmers in Russia. The resulting analysis discloses the economic drivers of these changes in cropping patterns which clearly indicate a lasting shift in the Black Soil Region towards corn and soybean production.

**KEYWORDS:** Russia; corn; focus group discussion; cropping pattern; on-farm competitiveness of crops

## 1. Introduction

### Background

The dissolution of the former Soviet Union set in motion the shift from the planned economy to a market economy. This structural modification of the political and, at the same time, the economic system has affected the agricultural sector. Starting in 1991, a significant decline in agriculture was observed; beginning in 2000, the entire sector, but especially crop production, headed toward a rapid recovery (Liefert & Liefert, 2012). The establishment of markets forced farmers to alter crop preferences based on prices and price ratios generated by the markets. New and interesting options were corn and soybeans.

Statistical analysis of Russian crop production reflected a significant rise in the cultivation of corn and soybeans – albeit beginning from a very low level. One of the strongest growth rates, and accounting for a significant share in the national output, can be found in the Central Black Soil Region (CBSR) (UniSIS, 2014). The question arises whether this change is a temporary occurrence, possibly driven by political interventions, or whether it reflects a fundamental change in crop economics which would imply a lasting change in cropping patterns.

When considering global crop production, a comparative example of fundamental change occurred during the past 20 years in southern Canada and the northern United States where corn and soybean production has expanded dramatically (Wright & Wimberly, 2013). Given the fact that there are climatic and agronomical similarities between the Central Black Soil Region and these North American regions, the question is whether the CBSR might evolve in a similar way in terms of cropping patterns. Given the size of the region and Russia's role in global grain markets in the long run this not only would have an impact on the development of the respective input and machinery markets, but also on global agricultural commodity markets.

### Aim of the paper

So far, very few articles about the expansion of these crops have been published in the Russian media (Vorotnikov, 2012; Munro, 2013; Doran, 2014). In science, this issue has not yet been addressed. For these reasons, this paper aims to identify drivers of a change in cropping patterns in the CBSR.

To achieve this objective, the first task is to illustrate the production development of the most important crops from 2000 to 2013. Secondly, this paper identifies economic drivers for the increase of corn and soybean production by comparing the profitability of corn and soybean production to the most important crop in the CBSR which is wheat. Finally, the authors draw conclusions regarding the drivers and perspectives for corn and soybean production in the CBSR.

### Organization of the paper

This paper is organized as follows: The second section reviews the development of the most important crops grown in the CBSR. The third section discusses the methods used in the paper. The benchmark, with an economic analysis of corn, soybeans and winter wheat is introduced in section four. The last part summarizes main findings and provides some conclusions.

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**Table 1:** Corn and soybean production in Russia – key parameters (2000 vs. 2013)

| Crop | Federal districts | Increase in acreage (% per year) | Increase in yield (% per year) | Share in national output (2000) | Share in national output (2013) |
|---|---|---|---|---|---|
| Corn | The Russian Federation | 10.2 | 5.7 | 100 % | 100 % |
| | Central Federal District | 17.3 | 6.8 | 19.2 % | 32.7 % |
| | Southern Federal District | 5.8 | 5.7 | 71.1 % | 37.8 % |
| | Volga Federal District | 15.4 | - | 8.9 % | 5.3 % |
| | Far Eastern Federal District | 14.9 | 7.9 | 0.7 % | 1.3 % |
| | Other | - | - | 0.0 % | 22.9 % |
| Soybeans | The Russian Federation | 10.2 | 3.4 | 100 % | 100 % |
| | Central Federal District | 32.8 | 6.6 | 1.9 % | 30.9 % |
| | Southern Federal District | 7.9 | 4.2 | 20.1 % | 20.9 % |
| | Volga Federal District | 29.1 | 5.6 | 0.5 % | 4.4 % |
| | Siberian Federal District | 17.7 | 0.9 | 1.4 % | 1.2 % |
| | Far Eastern Federal District | 8.1 | 2.9 | 76.0 % | 39.5 % |
| | Other | - | - | 0.1 % | 3.1 % |

Source: own calculations based on official statistics (UniSIS, 2014).

## 2. Evolution Of Cropping Patterns In Russia And The CBSR

### Selection of region for the study

Currently, the leading producer of corn in Russia is the Southern Federal District (see Table 1), a traditional area for corn cultivation, where the growth of acreage and yields was relatively small in the period studied. On the other hand, the Central Federal District has significantly increased its share of the national production; a change due to high growth rates of corn acreage and yield. At the same time, the Southern Federal District suffered a decline in market share.

Growth rates of soybean acreage reflect a geographical relocation of this crop to the west. In 2000, 76 % of soybeans were produced in the Far Eastern Federal District; its share dropped (despite an absolute increase in production) to 59 % by 2012 and to 39.5 % in 2013 (the latter decrease was in part driven by a massive crop loss as a result of severe flooding). Further increases in soybean plantings in the Far Eastern Federal District seem unlikely, as the share of this crop in the sown acreage already is 58.6 %. In the Amur region (part of the Far Eastern Federal District), which produces the majority of the district's soybeans, this proportion is even higher, at 70 %. Due to the high growth rates both in soybean acreage and yield in the Central Federal District, its share of the national output reached 30.9 % in 2013, while it was only 1.9 % in 2000.

The data cited show that the Central Federal District became a ''hot spot'' of corn and soybean in Russia. Since so-called ''Central Black Soil Region'' is a region defined by agro-ecological parameters and 94 % of the Central Federal Districts corn and 97 % of the soybean production takes place in the Black Soil Region this regional unit will be referred to in the remainder of the paper.

### Key characteristics of crop production in the CBSR

#### Natural and geographic conditions

Central Black Soil Region is one of 11 economic areas of the Russian Federation, which includes the regions of the southern part of Central Russia, such as Belgorod, Voronezh, Kursk, Lipetsk, Tambov and Orel (ASVR, 2014). The total sown area of the region in 2013 was 9.6 million ha, which is 12.3 % of the all cultivated land in Russia. The annual precipitation in the region varies between 518 mm and 648 mm and average annual temperatures range from 6.1 to 7.7 degrees Celsius (Climate, 2014).

#### Acreage and yields of major crops

Agricultural background information of a region requires knowledge about its most important crops. For this task, statistics regarding all agricultural land in the CBSR were analysed. In 2013, the largest share had cereals, with 59 % of the sown land in the CBSR. The largest share of cereals was winter wheat, with 27 % of the total cultivated area. Among non-grains, the largest acreage was planted to sunflowers, with 14 %. Sunflower was not planted by all farms studied. The authors compare winter wheat, so far the most popular crop, corn, and soybeans.

Figure 1 shows that the acreage cultivated with the observed crops is increasing. Because there has been a huge portion of the farm land being idle[3] this growth stems from (a) an increase in total cropped land and (b) shifts in cropping pattern in favour of winter wheat, corn and soybeans.

The 3.7 % average annual growth in land planted to winter wheat is the smallest among the analysed crops. With average growth rates of 17.2 % and 32.8 %, corn and soybeans show the highest annual increase in seeding. Whereas, in 2000, winter wheat was widely cultivated, corn and soybeans covered only 1.4 % of the CBSR's crop land; their growth spurt led to approximately 10 % of the cultivated land in 2013.

One possible explanation for this change in cropping patterns is the evolution of yields (Figure 2). Yields of winter wheat in the first phase of the analysed period were similar to or even better than those of corn. From 2003 onwards, the situation changed: corn yields improved significantly while wheat yields were almost flat. In 2012 corn yielded 2.5 tons per hectare more than winter wheat. Although soybeans in 13 years doubled its productivity, it has not reached the level of 2 tons per hectare.

Compared to the other crops the annual increase in wheat yields is almost flat at 1.5 % while soybeans and

[3] In the post-Soviet economic transition period, much land was abandoned. When analyzing the CBSR from 1990 to 2006 when arable land use was the lowest about 3.5 million hectares or 31 % were not cultivated. Starting in 2007, the trends reversed and in 2013 about 9.6 million hectares were cropped (or 83 % of the level of 1990).

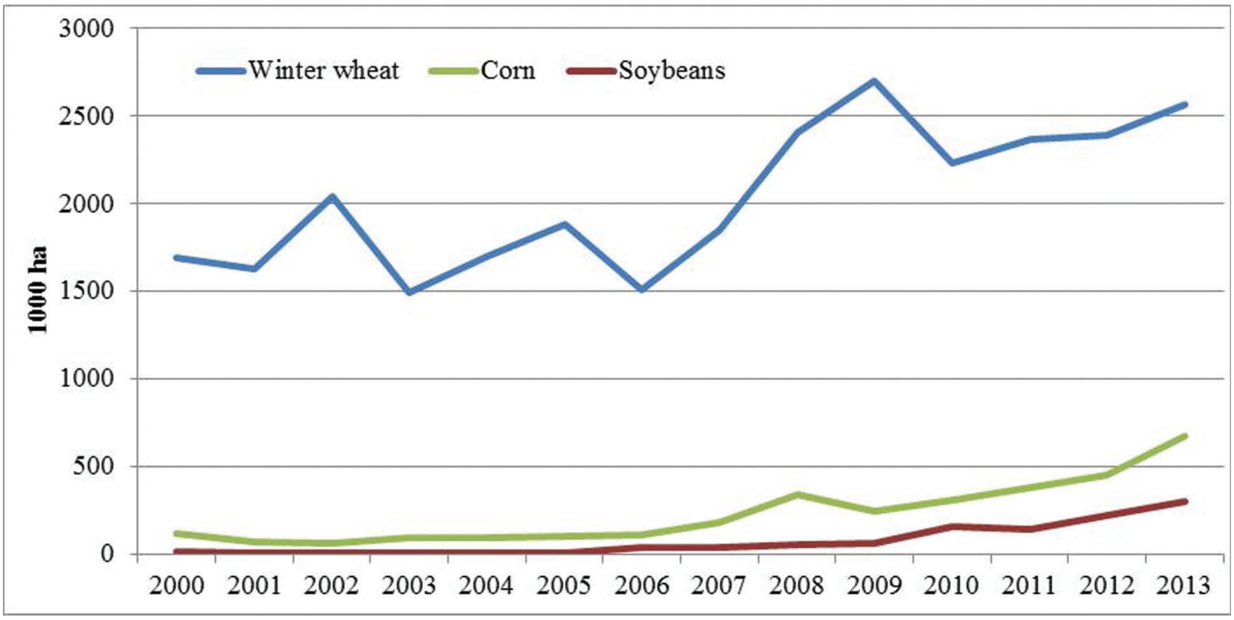


**Figure 1:** Evolution of selected crops' acreage in the CBSR
*Source*: UniSIS (2014) and own calculations

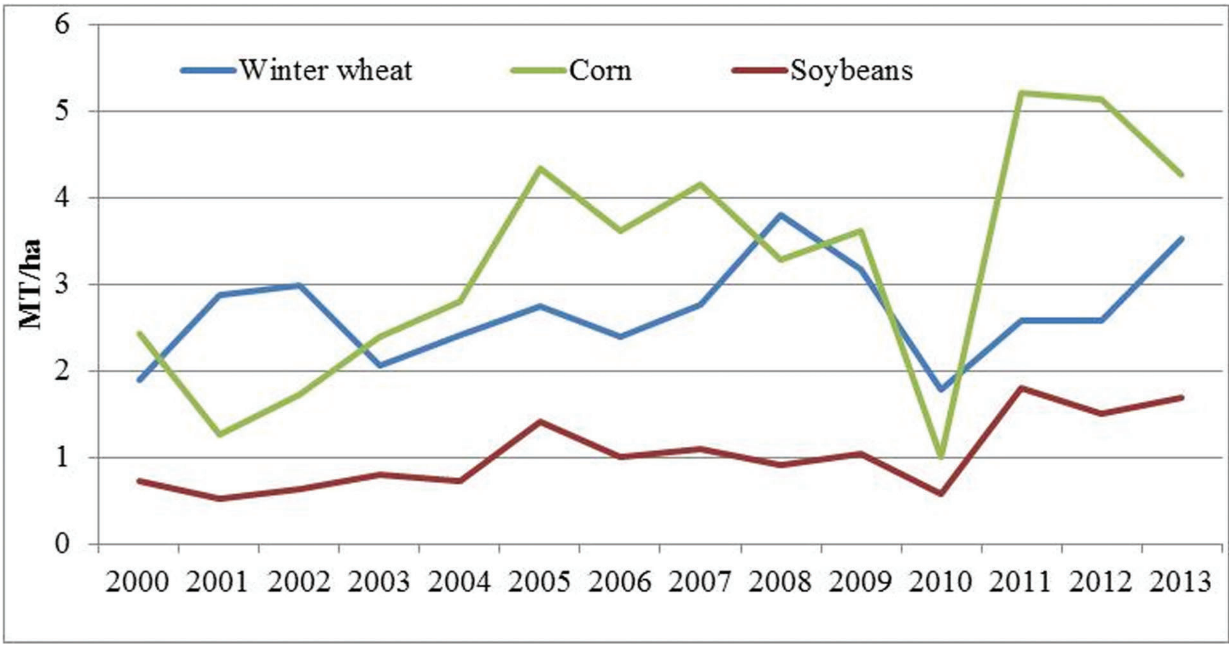


**Figure 2:** Yield (calculated as the output from the sown area) - evolution of the selected crops in the CBSR
*Source*: UniSIS (2014), own calculations

corn yields went up by 6.7 % and 6 % respectively. These annual rates were significantly influenced by the drought in 2010, when there was a major crop failure. When comparing the trend yield for 2010 based on a regression to the actual yields it appears that winter wheat yields only reached 64 % of the expected yield, in soybeans the value was 48 % and in corn only 28 %. When looking a production risks this comparison indicates that corn is much more susceptible to unfavourable weather conditions and therefore a riskier crop than the others.

**Farming structures**

Given the fact that corn and soybeans are somewhat ''non-traditional'' in the CBSR and expensive, it can be assumed that structural features of farms may have an impact on their willingness and ability to adopt these new options. Therefore, the subsequent section provides insights into the structure of farms and the importance of corn and soybeans for the different farm types.

Russian statistics distinguish three types of farms: agricultural enterprises, private farms and subsistence farms. Agricultural enterprises are large businesses, usually created on the basis of former collective and Soviet farms, often based on external capital and hired labour use. In many cases, such farms are consolidated in agro holdings. Private farms are usually smaller farms run by one person or with the assistance of family members and primarily based on joint labour input. Finally, a third form of agricultural producers is subsistence farms, predominantly producers who sell only their surpluses. This type of farm is widespread in Russia, but in particular relevant in livestock, fruits and vegetables.

Figure 3 indicates that, in corn, agricultural enterprises were able to increase their market share while, in the other crops, private farms expanded their market share. A possible explanation for this is that corn is a rather expensive crop. This fact is subject to further analysis, discussed later. Because access to credit and financial issues have an effect on the shift of crop patterns (Rao, 1989), this point might represent an advantage for agricultural enterprises over other farm types. The main reasons for this are the larger scale of production and diversification of the business (Chetvertakov, 2012). Therefore, farms with sufficient financial liquidity, in particular, are modifying their cropping patterns.

The following results from this section can be highlighted:

(1) CBSR is, indeed, a hot spot of Russian corn and soybean production, both in terms of growth in acreage and in yield improvement.
(2) While corn acreage went up by 17 % and soybeans by almost 33 %, wheat acreage increased by only 3.7 %.
(3) Regarding the differences in adopting new crops, agricultural enterprises seem to be more involved in corn and soybean production than the other two types of farms.

The next section illustrates the methodologic approaches and related assumptions used for further analysis.

## 3. Methods

Economic theory suggests that growers behave as profit maximizers, provided they operate under market conditions. When looking at cropping patterns and land use this assumption leads to the conclusion that profitability should be higher for those crops which have been able to expand their share in total acreage. Therefore, any attempt to identify the economic drivers for changes in cropping pattern requires a rather detailed set of data regarding input expenditures for individual crops.

Furthermore, the profitability of a certain crop is not necessarily a straight function of cost and revenue generated according to a profit and loss account. There may exist some very important economic drivers in grower's decision making which are non-monetary in nature: (a) rotational effects impacting the subsequent crop positively or negatively, (b) crops may differ in their risk profile (both in production risks and market risks), (c) they may have different peak-times in labour and machinery use and thereby creating different opportunity cost for those production factors and (d) sometimes their liquidity requirements are not the same and growers preferences are impacted differently than what results from an enterprise analysis based on P&L data suggest (see Albrecht, 2015).

One approach to gathering information regarding economic drivers is the use of official profit and loss figures reported by farms to local authorities in Russia. However, they cannot be used because of the following limitations:

- The level of information is too general – collected data are summarized at a regional level and do not represent single farms.
- These figures entail an inherent risk of being biased, as they were created for reports to tax authorities, possibly creating a strong incentive for producers to lower profits. Therefore, it is most likely that they do not reflect the true economic conditions.
- The absence of non-monetary data in these existing data makes it impossible to evaluate non-budgetary effects of individual crop choices.

In order to generate a realistic picture about economic drivers for growers' decisions it is therefore necessary to get (a) farm and even crop specific information and (b) growers' expertise regarding the importance and the "mode of action" of non-monetary effects associated with individual crops.

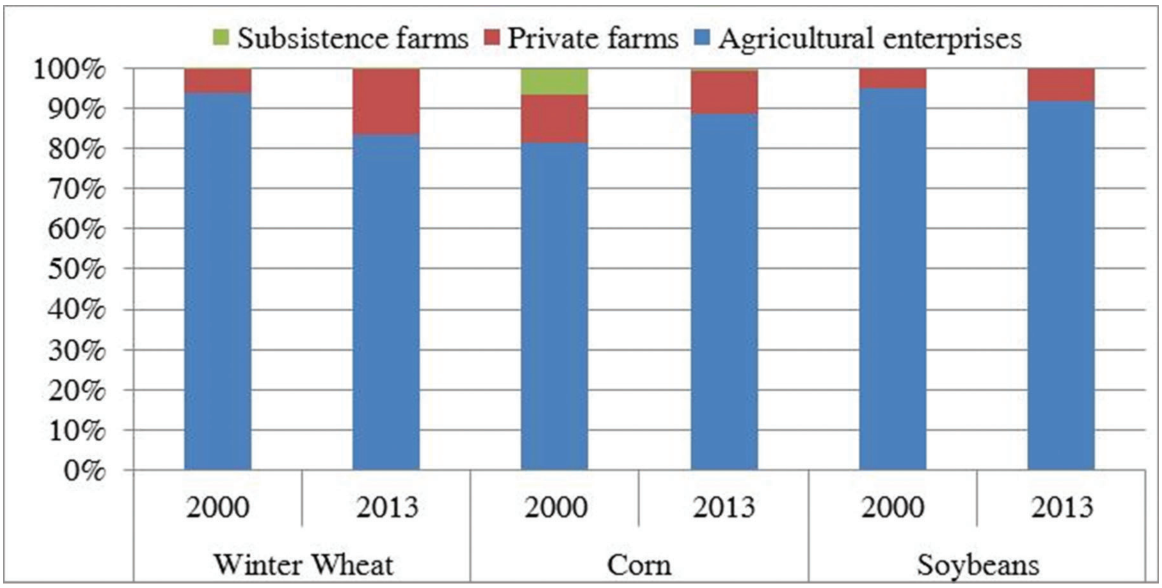


**Figure 3:** Importance of key crops for Russian farm types
*Source*: UniSIS (2014); own calculations

When following this approach, the next question arises: Which economic criteria should be used in order to evaluate economics of crop choices? Based on economic theory the ''return to land'' from a total cost and gross revenue analysis per crop would be the prime option. As of today, this figure is only available directly from *agri benchmark* data (see *agri benchmark*, 2015). This data base will be explained in greater detail below. The only shortcoming of this data base is that it does not contain any information on the non-monetary effects.

Given the shortcomings in official economic statistics, in theory the best option would be to collect complete farm and enterprise data on the individual crop level. Given existing budget restrictions for this project this was not a feasible option. Therefore, it seems reasonable to look for additional data sources from a case study in a so-called focus group discussion with a group of growers. The prime goal of this approach will be to (a) double-check key economic figures from the *agri benchmark* data set and (b) to evaluate the non-monetary effects associated with the crop choices. Details of the approach will be developed in more detail below.

## Typical farm approach

Data from typical farms generate in-depth insights regarding the economics of corn and soybean production in Russia. This method is used by *agri benchmark* Cash Crop, a non-profit global network of agricultural economists, advisors, producers and specialists in key sectors of crop value chains (*agri benchmark*, 2014).

The typical farm approach has the following characteristics:

- It represents the origin of a major share of crop output in a given country/region;
- Data are created by using available statistics as much as available;
- Information is usually gathered by local experts and growers;
- It contains data about quantities and prices for outputs, inputs, and production systems;
- The data are available for several years.

The database of *agri benchmark* contains information about one typical farm in the CBSR that will be used. However, it should be noted that establishing a typical farm in countries such as Russia faces some specific issues:

(1) Potential participants for the establishment of a typical farm are rare. There is a challenge in getting them together for focus group discussions and convincing them to speak openly because there is no culture of economic exchange.
(2) A typical farm cannot be established just with the help of an advisor – which is called a pre-panel typical farm - because they are not accessible. Simply substituting the pre-panel with an additional focus-group discussion of farm decision-makers probably also would not work as the necessary information is spread over many specialists, who, moreover, often do not know the required information off-hand. Such a focus group discussion would take too long and require too many people.
(3) The less developed expertise of growers and decision makers regarding the economics of their own businesses and the whole sector may cause uncertainty about the quality of the data obtained in the panel process (Walther, 2014).

Against this background the existing typical Russian farm in the *agri benchmark* data base reflects primarily the situation of one particular farm belonging to a large modernized holding.

## Focus group discussion

Despite the critical framework conditions experienced in previous work (see Walther, 2014) for the purpose of this study a focus group ''light'' approach has been designed and applied. Rather than trying to accomplish a total cost of production analysis the aim is to (a) generate a detailed variable cost analysis as well as a gross margin comparison for corn, soy and wheat and (b) to identify possible non-monetary effects of respective cropping decisions of growers or decision makers.

In order to do so one of the authors participated in the annual meeting of soybean growers of the Voronezh region in which the offer to more discuss economics of corn and soybean production was made to the participants. The resulting group consisted of five farmers, growing all three crops: wheat, corn and soybeans. All participants are responsible for their own agricultural business or are executive managers. Representatives of agroholdings did not attend and the participants therefore represented relatively small-scale farming for Russian conditions (fewer than 10,000 ha per farm).

The focus group discussion took place on November 12, 2014 in Voronezh. It was divided in two parts. The aim of the first part was creating an interest for crop economics comparison and generating a trustful and constructive atmosphere. For this part, the author presented analysis about the respective crop economics of a typical *agri benchmark* farm in the USA in North Dakota, where there is a lively competition between wheat and corn.

The second part of the meeting was devoted to the topic of typical production systems for corn, wheat and soybeans in the Voronezh region. In the course of a joint discussion among participants and the moderator a spreadsheet with all key cost elements as well as yield and product prices was completed (see Table 2). Even though there is not a culture of exchanging economic data among Russian growers a rather lively and open debate took place; it lasted for about 1 hour. This method made it possible to achieve the following:

(1) With a group of growers, it is easier to compare the whole range of figures and to find a representative type of operation/management for the given natural and economic framework conditions.
(2) Individual farmers might be reluctant to share sensitive individual economic data such as costs of production. Since the aim was to identify typical data for the region this obstacle could be overcome.

Given the different background of participants compared to the existing typical *agri benchmark* farm, which belongs to a large and relatively well equipped holding, it should be expected that results will be different.

In the next section, the results from the application of aforementioned methods will be presented.

 

**Table 2:** Typical direct cost, yields, prices and gross margin of wheat, corn, soybeans

| Key elements | Units | Wheat | Corn | Soybeans |
|---|---|---|---|---|
| Seeds | USD/ha | 69.9* | 114.0 | 54.7* |
| NPK cost | USD/ha | 71.3 | 99.8 | 34.2 |
| Amount of pure nutrients applied | kg/ha | 65 N, 10 P | 94.5 N, 13 P | 20 N, 12 P, 12 K |
| Herbicides | USD/ha | 34.2 | 42.8 | 34.2 |
| Other crop protection | USD/ha | 28.5 | 14.3 | 8.6 |
| Drying | USD/ha | | 147.2 | |
| Yield | MT/ha | 4.0 | 6.5 | 1.8 |
| Market price | USD/t | 203.5 | 169.6 | 418.3 |
| Direct cost | USD/ha | 203.9 | 418.1 | 131.7 |
| Revenue | USD/ha | 814 | 1102.4 | 752.9 |
| Gross margin | USD/ha | 610.1 | 684.3 | 621.2 |

*seed cost count 1/3 seeds as commercial and 2/3 as farm saved

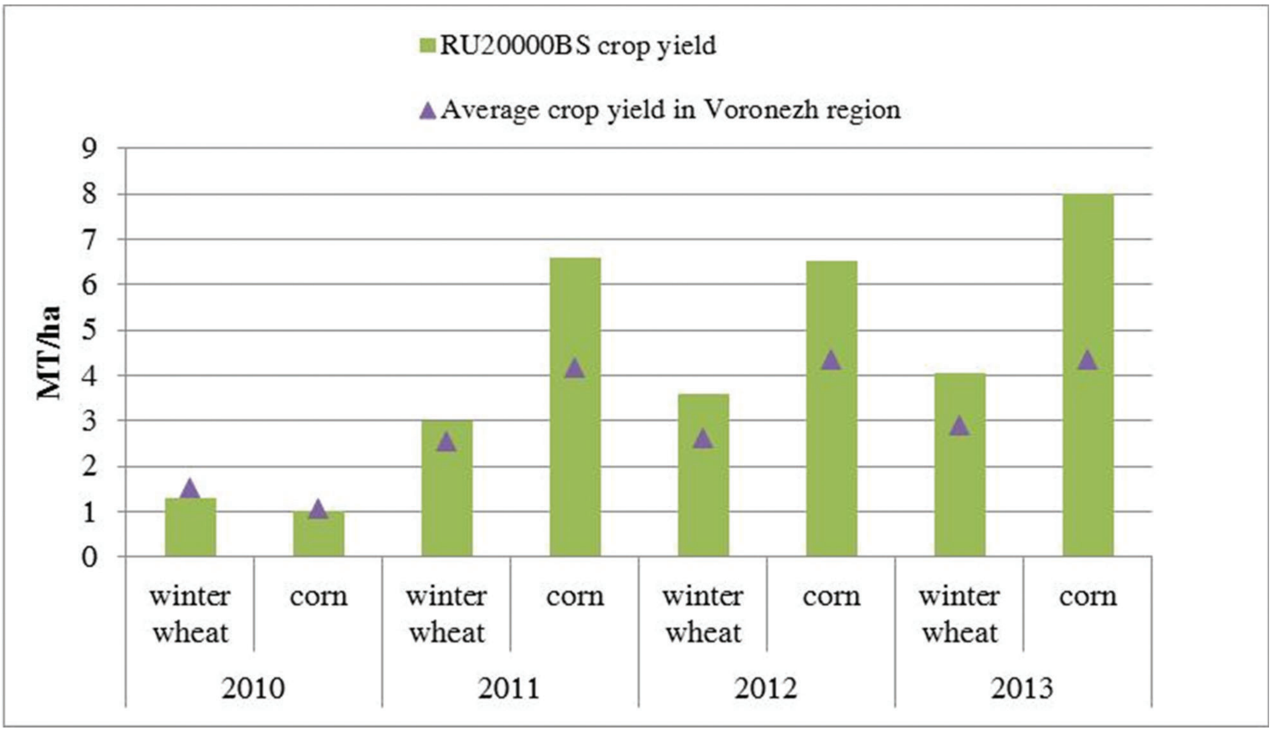


**Figure 4:** Winter wheat and corn yield for RU20000BS and the average in Voronezh region
*Source*: own calculations based on agri benchmark database and UniSIS (2014)

## 4. Economics And Farming Conditions Of The Major CBSR Arable Crops

As already mentioned, the most important crop in the CBSR is winter wheat. This is the only crop grown on all analysed farms and will therefore be used as a benchmark for the economics of corn and soybeans

### Typical farm

The review of economic indicators starts with a typical *agri benchmark* farm (abbreviated to RU20000BS). It has 20,000 hectares of arable land. Crops rotated there are winter wheat, spring wheat, winter rye, corn, spring barley, peas, and sunflower. Unfortunately, this farm does not grow soybeans. Key indicators for the analysis are shown in Figures 4 and 5.

In order to understand the performance of the agri benchmark farm and its position relative to its regional peers, Figure 4 shows the wheat and corn yields for this farm and the regional average. On the one hand it is remarkable that regional averages are significantly below the farm achievements. However, when looking at the subsequent figures from the focus group discussion (see Table 2) it appears that also under these circumstances actual yields are significantly higher than the regional averages based on official statistics. The poor yield in both data sets in 2010 can be explained by a severe drought. It should be noted that the yield of corn under these adverse conditions was less than the yield of winter wheat. In the other three years' corn yields were almost twice as high as wheat yields.

The total cost depicted in Figure 5 includes direct costs (seeds, fertilizers and crop protection) and operating costs (labour, machinery, contractor and diesel), building cost, land, and miscellaneous cost. The market revenue was calculated as gross yield multiplied by ex-farm prices. The difference between the market revenue and the total cost is the profit.

Due to the high cost and lower market revenue of corn compared with wheat, the unfavourable weather

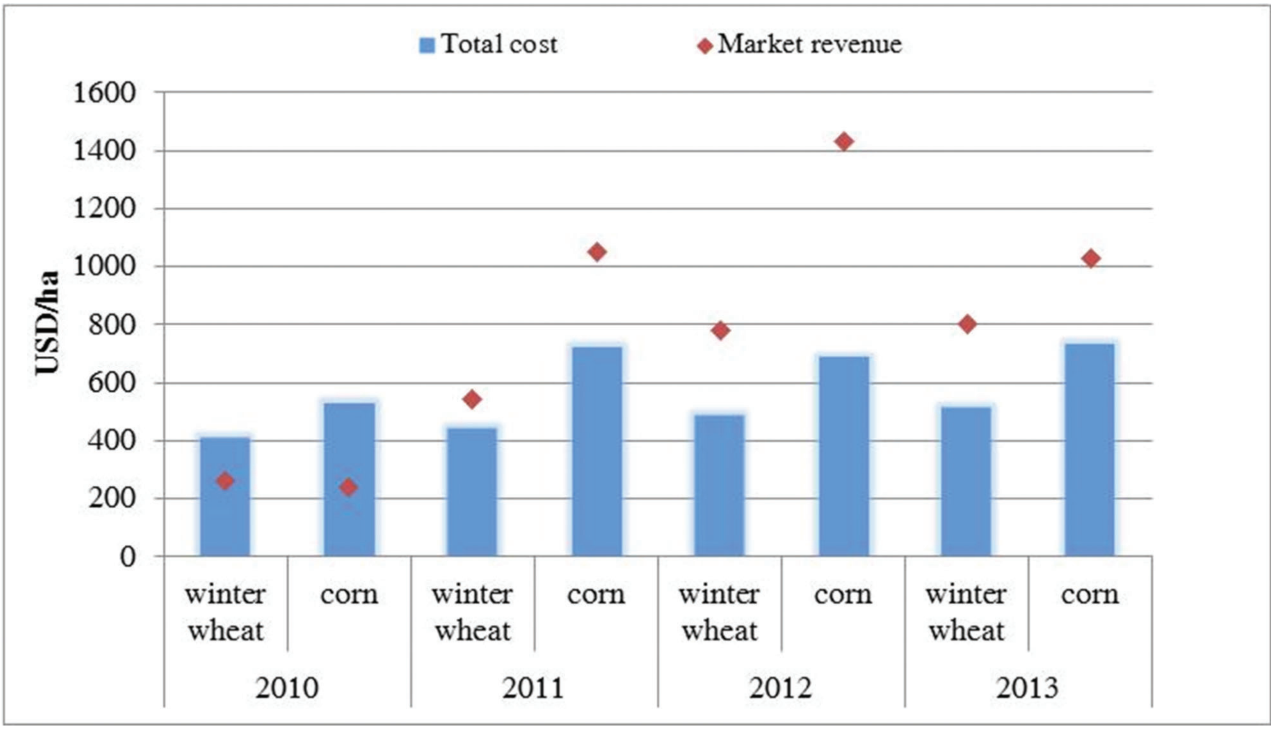


**Figure 5:** Winter wheat, corn revenue and total cost for RU20000BS
*Source*: agri benchmark database and own calculations

conditions in 2010 caused much higher economic losses for corn (287 USD/ha) than for wheat (148 USD/ha). However, for the other three years in this comparison, the profit per hectare of corn was higher than per hectare of wheat: 234 USD/ha in 2011, 452 USD/ha in 2012 and 7 USD/ha in 2013. The reason for the significant decline in the advantage in profit of corn over wheat was a sharp reduction of relative corn prices in 2013. However, all in all one can conclude that there is good reason to assume that in recent years' corn tended to be more profitable than wheat and thereby the economics were indeed a key driver for the rapid expansion of corn acreage in the CBSR.

## The focus group discussion

The focus group discussion resulted in a compilation of direct cost, yields, and prices for selected crops, as presented in Table 2. To understand the method of calculation, some details have to be explained. Costs and prices are given on a factual basis for 2014; whereas yield figures are based on multi-annual expectation of growers participating in the focus group discussion (not factual).

In 2014, the Russian rubble experienced a significant devaluation, which caused a conversion issue. Of course, in an ideal situation one would use the exchange rate for the day the transactions took place, but these dates are not available. To minimize inaccuracies and to present a most realistic picture, an average exchange rate to the US dollar was used. For costs, the average exchange rate was calculated from January 1, 2014 to May 31, 2014, the time span during which the bulk of input purchases takes place. For output prices, the exchange rate was calculated for the period October 29, 2014 to November 11, 2014, the two weeks prior to the focus group discussion. However, it should be noted that any imperfection of the approach does not affect the comparison between the different crops.

Seed cost in the table result from one third of wheat and soybeans seed being commercially bought while the remainder is farm saved seeds. This reflects the actual practice of the growers participating in this focus group discussion. The figures presented in Table 2 therefore are comprised of the two sources: farm saved seed where valued by its opportunity cost; the price of commercial grains and commercial seed.

The gross margin is calculated on the basis of direct cost (which is the sum of seed, fertilizers, herbicides, other pesticides, and drying of corn) and revenue (calculated as market price multiplied by yield). It appears that corn generated the highest margin, USD 74 more than wheat. Growing soybeans yields USD 11 more than wheat. When looking at the details for cost in corn it can be seen that the majority of direct cost is drying cost. This figure indicates an elevator charge for this service for a corn crop with an initial moisture content of 25 %; the elevator's profit is included. Given the lack of on-farm drying capacities this figure represents the current economic conditions for most growers in the region.

However, in the long run this picture might change with on-farm investments in drying equipment. Therefore, we also calculated the corn gross margin with on-farm drying. Since there is no data available for on-farm drying cost in Russia a respective calculation from an official crop budget from North Dakota (USA) (Crop budgets, 2014) is used as a first approximation. This source estimates the on-farm drying cost (fuel, depreciation, finance, labour) at about USD 70 per ha for the corn conditions in the table. When using this figure for the calculation instead of the service fees charged by elevators, the advantage of corn over wheat margin increases to approximately USD 150/ha. Such an increase would most likely strengthen the trend to produce corn. Another factor playing in favour of corn is the recent decline in oil prices. Due to the massive drop in global, and subsequently Russian oil prices, drying cost should have gone down significantly as well. Therefore, the competitiveness of corn has increased even more.

However, gross margins are not the only factor considered by farmers. Different crops have different effects on subsequent crops, they have different risk profiles and they differ regarding labour and machinery use during peak times. To identify properties of the analysed crops that are not reflected in the crop budget, the group was asked for effects that have an influence on their decisions. There was also an open question for additional effects that could have been missed by the authors.

Answers revealed that farmers do not consider special risks of individual crops; all crops are assumed to be risky. Moreover, neither agronomic complexity nor other issues (marketing, timing, trusted partners) influence the crop decision. An additional economic stimulus that can influence farmers' crop decision is subsidies. According to the farmers, there can be more subsidies for one crop than for another, but the differences are rather insignificant and usually are not taken into consideration when taking cropping decisions. When asked about their future plans regarding cropping patterns, none of the participating farmers had a specific inclination to increase the corn ratio in their rotations. The main reason: adding more corn acreage would imply the need to make additional investments in equipment for seeding, harvesting and storage. Regarding soybeans, some farmers expressed an interest in increase acreage. This willingness in favour of soy can be interpreted as a result of a smaller threshold between wheat and soybeans in comparison to corn.

## 5. Conclusions

Economic analysis of farm data suggests that the strong growth in corn and soybean production in the CBSR in Russia is indeed driven by rather high profitability when compared to wheat. An advantage of more than 100 USD/ha in profit or gross margin is considered to be a very strong incentive to shift cropping patterns. The outcome from the focus group discussion reinforced the results generated through the existing typical agri benchmark farm, even though as expected actual data were different.

Given the high importance of drying cost and the fact that currently many producers in the CBSR rely on rather expensive services from elevators there is room for an additional increase in corn margins compared to wheat. Of course this is subject to significant additional investments at the farm level, which are subject to the availability of loans and interest rates. Taking into account trends in yield for corn vs. wheat in the CBSR it has to be assumed that in future the fundamentals will develop even more in favour of corn.

Even though theoretical considerations do suggest a higher economic risk to produce corn compared to wheat, growers participating in the focus group discussion were not concerned about this issue. They also did not mention any rotational effects or other non-monetary effects associated with these crops. Whether this means those effects do not exist at all in the CBSR or whether growers participating in the focus group discussion were not yet as sophisticated operators as their colleagues in the West remains to be seen.

Despite these results the growers participating in the focus group discussion were not considering significantly expanding their acreage seeded to corn but were eager to increase their soybean acreage. When looking at increasing corn, they were concerned about the associated need for additional investments needed in equipment. Given high interest rates this does reflect the current situation but of course it does not exclude a mid- to long term shift. It also does not mean that new growers will not start to produce corn.

With regard to the methodology it turns out that in principle the globally applied focus group approach did work in Russia as well. However, it should be noted that this first test of the concept was done with a less sophisticated version by only asking for gross margin figures.

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# Risk adjusted cost efficiency indices

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**ABSTRACT**

This paper examines the impact of risk on cost efficiency for a sample of farms. Cost efficiency was estimated using traditional input and output measures, and then re-estimated including each farm's downside risk measure. Downside risk was defined as the percent of years in which a farm's net farm income did not cover unpaid family and operator labour. Comparisons were made with and without a change in efficiency when each farm's downside risk measure was included in the analysis. As expected, downside risk plays an important role in explaining farm inefficiency. Failure to account for downside risk overstates inefficiency, particularly for farms with low downside risk measures.

**KEYWORDS:** Efficiency; downside risk; data envelope analysis

## 1. Introduction

Cost efficiency indices are used to examine resource use and product mix. Farms that are cost efficient are using the optimal mix of inputs and outputs. Inputs and outputs of inefficient farms are typically compared to the cost of efficient farms. Through this process, benchmarks are created and suggestions for improvements on inefficient farms can be made.

Even though risk can have a large impact on decision making, previous literature that adjusts cost efficiency scores for differences in risk among farms is very limited. Only a small handful of studies have examined risk or undesirable outputs (Mester, 1996; Chang, 1999; Färe, Grosskopf, and Weber, 2004; Färe and Grosskopf, 2005). These studies focused on banking and environmental issues. None of these studies examined the impact of risk on efficiency scores for a sample of farms.

The primary objective of this paper is to examine the impact of risk on cost efficiency for a sample of farms. Cost efficiency for farms with various degrees of risk was compared. Cost efficiency indices were also compared across farm size and farm type categories. This paper adds to the existing literature by providing a justification for adjusting cost efficiency scores for downside risk, illustrating a method to do so, and making comparisons of efficiency scores with and without risk considerations.

## 2. Methods

Various methods can be used to measure cost efficiency. Data envelope analysis (DEA) or the nonparametric approach is used to measure cost efficiency in this paper because it does not impose restrictions on the underlying technology set that would be imposed if a parametric approach was used and is flexible in calculating and decomposing efficiency measures. DEA is a linear programming technique used to measure relative efficiencies where the estimated efficiencies represent upper bounds to the true efficiencies. DEA is chosen because it does not impose a functional form on the relationship between outputs and inputs, thus mitigating errors associated with imposing an inappropriate model structure (Färe and Grosskopf, 1996; Coelli *et al.*, 2005).

Cost efficiency measures are relative to other farms in the data set. Even though risk often impacts the input and output mix chosen by decision makers (Robison and Barry, 1987), risk is typically not included in efficiency estimates. Inefficiency estimates that do not include risk may overstate the degree of inefficiency exhibited by individual farms, particularly if risk varies substantially among farms. With this in mind, a risk measure is included in cost efficiency analysis in this paper to disentangle risk and inefficiency.

Cost efficiency (CE) can be determined by dividing the minimum cost under variable returns to scale by the actual cost observed by the farm:

$$CE = c_i' x_i^* / c_i' x_i \tag{1}$$

where $c$ is a vector of input prices, $x$ is a vector of input levels used, $i$ signifies the firm of interest, and * indicates the optimal value (Färe, Grosskopf, and Lovell, 1985; Coelli *et al.*, 2005).

The denominator in equation (1) is the actual cost for the individual farm, the numerator is determined for each farm using the following linear programme:

$$Min_{x^*} c_i' x_i^* \tag{2}$$

subject to:

$$\begin{gathered}
x_{11}z_1 + x_{12}z_2 + \ldots + x_{1k}z_k \leq x_{1i}^* \\
x_{21}z_1 + x_{22}z_2 + \ldots + x_{2k}z_k \leq x_{2i}^* \\
\ldots \\
x_{n1}z_1 + x_{n2}z_2 + \ldots + x_{nk}z_k \leq x_{ni}^* \\
y_{11}z_1 + y_{12}z_2 + \ldots + y_{1k}z_k - y_{1i} \geq 0
\end{gathered}$$

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$$\ldots$$
$$y_{m1}z_1 + y_{m2}z_2 + \ldots + y_{mk}z_k - y_{mi} \geq 0$$
$$z_1 + z_2 + \ldots + z_k = 1$$

where *c, x,* and *i* are as previously defined; *y* is a vector of outputs; the subscript *k* denotes the number of farms; the subscript *n* is the number of inputs; the subscript *m* is the number of outputs; $z_k \in \Re^+$, measures the intensity of use of the k$^{th}$ farm's technology; and * indicates the optimal value (Färe, Grosskopf, and Lovell, 1985; Coelli *et al.*, 2005).

Farms with a cost efficiency index of 1 are producing on the production possibility and cost frontiers, and are using the optimal mix of inputs. Inefficient farms have a cost efficiency index between 0 and 1, with a lower index indicating a greater degree of inefficiency.

Cost efficiency indices are first estimated without the inclusion of a risk measure. The efficiency scores are then estimated a second time including each farm's risk measure as a non-discretionary input. A non-discretionary input is equivalent to a ''bad output'' and represents an input the manager has little to no control over. Therefore, the model is structured to seek a reduction in the inputs over which the manager does have control (Coelli *et al.*, 2005). To incorporate risk, the linear program (2) is modified by adding the additional constraint below:

$$r_1z_1 + r_2z_2 + \ldots + r_kz_k \leq r_i \tag{3}$$

where *i, k,* and $z_k$ are as previously defined; and *r* is a measure of risk. Note that the risk measure is included as an input constraint, but it is not a choice variable in the optimization.

Downside risk is used as the risk measure in this study. Measuring downside risk, an asymmetric measure of risk that focuses on the left tail of the return distribution, may more accurately address producers' concerns because it identifies returns below a specified target or benchmark return level which is often more troublesome than the traditional variance or standard deviation measure (Hardaker *et al.*, 2004). Downside risk typically focuses on the probability of having low outcomes or the magnitude of low outcomes below a target threshold (Barry, 1984; Hardaker *et al.*, 2004). In this study, operations with no downside risk have a net farm income large enough to cover all cash costs and depreciation plus unpaid family and operator labour. However, if an operation is not able to cover all of their unpaid family and operator labour, they may be currently covering all cash and depreciation expenses, but they do not have a positive return to equity and are at risk because they cannot operate without covering all costs indefinitely.

Following Langemeier and Jones (2001), downside risk is defined as the percent of years in which a farm's net farm income does not cover unpaid family and operator labour. For example, a downside risk score of 0.50 would indicate that in 50 percent of the years in the sample, the farm's net farm income was not high enough to cover unpaid family and operator labour. The downside risk measure captures ten years of data in an attempt to mitigate the effects of weather, yields, and prices from one or two years and instead illustrates risk over time. This contributes to the importance of this measure because not covering unpaid family and operator labour for 1-3 years while difficult, is likely still sustainable. Not being able to cover unpaid family and operator labour for a majority of the years, indicates a significant problem.

Cost efficiency scores with and without downside risk are computed for each farm using the equations above. Following equation (1), cost efficiency without risk is computed by dividing (2) by actual cost. Cost efficiency with risk is computed by adding the additional constraint (3) to linear program (2) and dividing by actual cost.

Cost efficiency scores or indices with and without downside risk are compared among farms with different levels of downside risk and among farm size categories. Farms are further divided into two categories, farms with no change in cost efficiency with the inclusion of risk and farms with a change in their cost efficiency index with the inclusion of risk, to determine whether farm size, income shares, cost shares, and financial measures vary among farms with and without a change in cost efficiency with the inclusion of downside risk. T-tests are used to determine whether the differences among the two categories are significant at the five percent level.

## 3. Data

The 649 farms included in this study were members of the Kansas Farm Management Association (KFMA) and had continuous whole-farm data for the 2002 to 2011 period. Efficiency estimates required data on total cost, outputs, inputs, and input prices. Data pertaining to total cost, outputs, and inputs for the 649 farms were obtained from the Kansas Farm Management Association (KFMA) databank. With the exception of the labour input, USDA price indices were used to develop an input price index for each input. The price for labour was obtained from the KFMA databank. Though annual data were available for each farm, ten-year average data were used in this study to reduce the impact of weather in a particular year on efficiency estimates. Downside risk, the percent of years in which a farm's net farm income did not cover unpaid family and operator labour, was computed for each farm using all ten years of data.

Five inputs were used in the analysis: labour, crop input, fuel and utilities, livestock input, and capital. All costs, including those for machinery and land, were annualized. Labour was represented by the number of workers (hired labour, and unpaid family and operator labour) on the farm and labour price was obtained by dividing labour cost by the number of workers. Implicit input quantities for the crop input, fuel and utilities, the livestock input, and capital were computed by dividing the respective inputs' costs by USDA input price indices. The crop input consisted of seed; fertilizer; herbicide and insecticide; crop marketing and storage; and crop insurance. Fuel and utilities were comprised of fuel, auto expense, irrigation energy, and utilities. The livestock input included dairy expense; purchased feed; veterinarian expense; and livestock marketing and breeding. The capital input included repairs; machine hire; general farm insurance; property taxes; organization fees, publications, and travel; conservation; interest; cash rent; depreciation; and interest charge on net worth (Langemeier, 2010).

**Table 1:** Summary statistics for sample of Kansas farms

| | Units | Average | Standard Deviation |
|---|---|---|---|
| **Inputs** | | | |
| Labor | Number of workers | 1.38 | 0.83 |
| Crop | Implicit quantity | 139,445 | 128,919 |
| Fuel and Utilities | Implicit quantity | 43,403 | 46,332 |
| Livestock | Implicit quantity | 47,801 | 173,518 |
| Capital | Implicit quantity | 204,818 | 145,748 |
| **Outputs** | | | |
| Crop | Implicit quantity | 505,976 | 483,287 |
| Livestock | Implicit quantity | 98,473 | 221,113 |
| **Risk Measure** | | | |
| Downside Risk | Percent of years | 44.48% | 30.09% |
| **Farm Characteristics** | | | |
| Value of Farm Production | Dollars | 360,023 | 308,968 |
| Net Farm Income | Dollars | 88,322 | 94,915 |
| Corn Income | Dollars | 74,374 | 140,558 |
| Grain Sorghum Income | Dollars | 21,412 | 31,711 |
| Hay and Forage Income | Dollars | 13,054 | 34,441 |
| Oilseed Income | Dollars | 77,166 | 93,286 |
| Small Grains Income | Dollars | 61,813 | 69,380 |
| Beef Income | Dollars | 73,523 | 178,913 |
| Dairy Income | Dollars | 471 | 4,972 |
| Swine Income | Dollars | 2,147 | 18,653 |
| **Financial Measures** | | | |
| Operating Profit Margin Rate | Ratio in decimal form | 0.0629 | 0.2333 |
| Asset Turnover Ratio | Ratio in decimal form | 0.3321 | 0.2017 |
| Rate of Return on Investment | Ratio in decimal form | 0.0307 | 0.0651 |

Source: Kansas Farm Management Association Databank, 2012.

Outputs included crop and livestock. Implicit crop and livestock quantities were computed by dividing crop income and livestock income by USDA crop price and livestock prices indices for Kansas.

The summary statistics are presented in Table 1. On average, 44 percent of the time the farms' net farm income was not large enough to cover unpaid family and operator labour. The average value of farm production for the sample farms was $360,023[3]. Net farm income averaged $88,322. Though not shown in Table 1 the average number of hectares (irrigated crop land, non-irrigated crop land, pasture, and farmstead) was 815 and the average amount of unpaid family and operator labour was $49,879. The largest three sources of crop income were oilseeds (which consisted primarily of soybeans), corn, and small grains (which consisted almost exclusively of wheat). Beef income accounted for almost all of the livestock income. The average profit margin and asset turnover ratios were 0.0629 and 0.3321, respectively. The average rate of return on investment was 0.0307. It is important to note that this rate of return excludes capital gains on land.

## 4. Results

The average cost efficiency for the 649 farms in this study are included in Table 2. The average cost efficiency index without risk was 0.745. With the addition of downside risk, the average cost efficiency index increased to 0.754. In other words, the downside risk measure explained 3.53 percent of the cost inefficiency on average for all farms. Also, the number of farms on the cost frontier (i.e., cost efficiency index of 1) increased from 8 to 23 with the addition of downside risk. Indicating that for 15 farms, downside risk explained their entire relative inefficiency.

[3]At the time of submission (mid-January 2016), $US1 was approximately equivalent to £0.70 and €0.92.

**Table 2:** Average cost efficiency measures for sample of farms

| | Without Risk | With Risk |
|---|---|---|
| **Efficiency Measures** | | |
| Average | 0.745 | 0.754 |
| Standard Deviation | 0.109 | 0.115 |
| Minimum | 0.351 | 0.351 |
| Number Equal to One | 8 | 23 |
| **Downside Risk - Number of Years** | | |
| 0 Years (51 farms) | 0.828 | 0.856 |
| 1 to 3 Years (238 farms) | 0.797 | 0.808 |
| 4 to 6 Years (181 farms) | 0.729 | 0.739 |
| 7 to 9 Years (131 farms) | 0.679 | 0.682 |
| 10 Years (48 farms) | 0.634 | 0.634 |
| **Farm Size - Value of Farm Production** | | |
| Less than $100,000 | 0.678 | 0.697 |
| $100,000 to $249,999 | 0.711 | 0.723 |
| $250,000 to $499,999 | 0.768 | 0.773 |
| $500,000 or More | 0.796 | 0.803 |

Average cost efficiency decreased as downside risk increased for both the cost efficiency measures with and without risk. Note that less than 10 percent of the farms had either no downside risk or downside risk in all ten years. In other words, it was common to have at least some downside risk. It is clearly evident in table 2 that the difference between cost efficiency with and without downside risk widened as downside risk decreased. There was not a difference in the measures for the farms with downside risk in every year. In contrast, the difference between the two measures for farms with no downside risk averaged

**Table 3:** Average farm characteristics by changes in cost efficiency

| | No Change with Risk | Change with Risk | Significant |
|---|---|---|---|
| Number of Farms | 245 | 404 | |
| **Efficiency Measures** | | | |
| Cost Efficiency without Risk | 0.714 | 0.763 | Yes |
| Cost Efficiency with Risk | 0.714 | 0.779 | Yes |
| **Risk Measure** | | | |
| Downside Risk | 59.67% | 35.27% | Yes |
| **Farm Size** | | | |
| Value of Farm Production | $432,959 | $315,792 | Yes |
| Net Farm Income | $85,818 | $89,841 | No |
| **Income Source** | | | |
| Percent of VFP from Corn Income | 13.88% | 15.94% | No |
| Percent of VFP from Grain Sorghum Income | 5.49% | 7.47% | Yes |
| Percent of VFP from Hay and Forage Income | 5.03% | 3.49% | Yes |
| Percent of VFP from Oilseed Income | 17.29% | 22.51% | Yes |
| Percent of VFP from Small Grain Income | 19.10% | 18.85% | No |
| Percent of VFP from Beef Income | 30.51% | 19.31% | Yes |
| Percent of VFP from Dairy Income | 0.25% | 0.10% | No |
| Percent of VFP from Swine Income | 0.74% | 0.49% | No |
| **Cost Share** | | | |
| Percent of Input Cost from Labor | 17.79% | 17.01% | No |
| Percent of Input Cost from Crop Input | 22.69% | 24.81% | Yes |
| Percent of Input Cost from Fuel and Utilities | 6.99% | 6.50% | Yes |
| Percent of Input Cost from Livestock Input | 8.21% | 4.20% | Yes |
| Percent of Input Cost from Capital | 44.32% | 47.48% | Yes |
| **Financial Measures** | | | |
| Operating Profit Margin Ratio | -0.0333 | 0.1212 | Yes |
| Asset Turnover Ratio | 0.3543 | 0.3187 | Yes |
| Rate of Return on Investment | 0.0084 | 0.0441 | Yes |

0.028. Farms with more downside risk remained less efficient while farms with less downside risk saw an improvement in their relative efficiency when risk was considered.

Cost efficiency with and without downside risk is also summarized by farm size category in Table 2. Differences in efficiency between the two cost efficiency measures were largest for the farms in the smallest farm size category and smallest for the farms in the $250,000 to $499,000 farm size category. Cost efficiency increases with farm size for the indices with and without downside risk. This indicates that farms are taking advantage of economies of scale. With the inclusion of downside risk, cost efficiency increases from 0.678 to 0.697 for the smallest farm size category and from 0.796 to 0.803 for the largest farm size category. Once accounting for downside risk, the farms are relatively less inefficient than before and smaller farms based on value of farm production have more room to improve.

To further understand the impact of the inclusion of downside risk, the farms were divided into two categories based on whether the farms experienced a change in cost efficiency with the inclusion of downside risk. Table 3 provides the characteristics of the 245 farms with no change in efficiency and the 404 farms with a change in efficiency as well as statistical significance at the 5 percent level. The change in efficiency for the 404 farms ranged from a very small change (0.001) to a change of 0.254. On average, the farms that experienced a change in their efficiency score had less downside risk; were smaller; had a higher proportion of income from grain sorghum and oilseeds; a lower proportion of income from hay and forage, and beef; higher cost shares for the crop input and capital; lower cost shares for fuel and utilities and the livestock input; and had a higher rate of return on investment.

## 5. Conclusions

Cost efficiency with and without the inclusion of downside risk was estimated for 649 Kansas Farm Management Association farms with continuous data for the 2002 to 2011 period. Outputs included crop and livestock. Inputs included labour, crop input, fuel and utilities, livestock input, and capital. Downside risk was measured as the percentage of years in which a farm's net farm income did not cover unpaid family and operator labour. The average cost efficiency for the 649 farms was 0.745 and increased to 0.754 with the inclusion of downside risk.

The largest increase in cost efficiency with the inclusion of downside risk was for the farms with lower levels of downside risk. In contrast, the increases for farms with high levels of downside risk were negligible. This suggests that excluding downside risk overstated the relative inefficiency of the farms with low levels of downside risk and understated the relative inefficiency of farms with high levels of downside risk. On average, cost efficiency was higher for larger farms. This is an indication that these farms are taking advantage of economies of scale; however, it does not mean that small farms cannot be efficient. All farms need to focus on controlling expenses in order to increase net farm income and efficiency.

Cost efficiency differences among the farms with no change in efficiency and a change in efficiency with the inclusion of downside risk varied by farm size and type. Farms with a change in cost efficiency with inclusion of downside risk were smaller. These farms also had a lower proportion of their income coming from hay and forage, and beef; a higher proportion of their income coming from grain sorghum and oilseed; and a higher rate of return on investment.

For some farms, downside risk as measured in this study did not affect their cost efficiency. These farms have more opportunities to increase efficiency through better management and utilization. For other farms, risk is a major hindrance and in some instances (15 farms) downside risk explained the entire inefficiency of the farm.

In conclusion, including downside risk had a significant impact on relative cost efficiency measures. Thus, traditional efficiency measures that exclude risk may provide inaccurate benchmarks, particularly for farms with low levels of downside risk.

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# Farm succession in Texas: A qualitative approach

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**ABSTRACT**

Family farm succession methods vary considerably due to individual family dynamics. This study uses qualitative research methods to investigate the impacts of farm business structure, division of managerial responsibility, and family decision-making processes on the matter of business transfer from one generation to the next. Interview methods were employed to investigate succession methods in the northern and southern high plains of Texas. Results indicate that succession methods vary across individual families. The method by which the younger generation becomes involved in farming, as well as family dynamics, are found to impact farm succession.

**KEYWORDS:** family farms; interview; qualitative research; succession

## 1. Introduction

The infusion of young farmers into agricultural production occupations is a vital element in the quest for continued development and sustainability of farming operations worldwide (Cassidy and McGrath 2014; Chiswell 2014; Fischer and Burton 2014; Lobley 2010; Lobley, Baker, and Whitehead 2012). This study utilizes a qualitative interview approach to provide insight into the motives behind the methods in which the younger generation enters the farming profession. According to the United States Department of Agriculture (USDA) Economic Research Service (ERS) approximately 99 percent of United States' farm businesses are family operations; as such, a primary concern for many farm families is maintaining the family farm business for multiple generations (Hoppe and MacDonald 2016). This process can be extremely turbulent and complicated, because each family undergoing a farm business transfer will encounter unique issues and concerns (Burton and Walford 2005; Cassidy and McGrath 2014; Chiswell 2014; Silvasti 2003).

There are many different methods by which families can assist the younger generation during their entry into farming. Regardless of how the younger generation enters into the farming profession, the decisions made during the younger generation's entry process can have tremendous impacts on the economic profitability of the farm business. When determining the means by which the younger generation should enter farming, the ultimate goals are to maintain the economic viability of the farm business while maximizing family welfare (Burton and Walford 2005; Chiswell 2014; Fischer and Burton 2014; Lobley 2010; Lobley, Baker, and Whitehead 2012).

Due to the highly distinct nature of family farm transfers, quantitative analyses may fail to fully recognize individual family dynamics related to the transfer process (Uchiyama et al. 2008). An alternative for investigating the inner workings of the family farm transfer process is to approach the research question qualitatively. Rather than attempting to measure and quantify complex social issues between family members, a qualitative research approach offers the ability to see inside the family unit and analyze individual family concerns and issues. Considerable recent research on family farm transitions has made use of qualitative methods (Cassidy and McGrath 2014; Fischer and Burton 2014; Price and Conn 2012; Riley 2009; Riley 2014; Silvasti 2003). This study used interview methods to examine family farm transfer issues in farm families either planning to undergo or involved in the farm transfer process. Specifically, this study investigated family demographics, farm structure, distribution of managerial responsibilities, and family involvement in decision-making processes which impacted the succession decisions of farm families in the High Plains of Texas.

## 2. Literature Review

Family farming is a specialized form of family business. As with other types of family businesses, families engaged in farming must address not only the business aspects, but must also ensure that familial needs are addressed. Farming is unique in that family farms are very likely to be passed on to another generation. The likelihood of family farms being passed on to the next generation can be up to nine times greater than other types of family businesses (Laband and Lentz 1983). Often, a family

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farm has been in the family for generations and is assumed likely to remain in the family's possession for subsequent generations.

## Family farm business transfers

Succession transition methods for family farms often mirror those of any other type of family business, although farms are unique in their problems associated with entry and exit of generations. Boehlje (1973) identified five unique characteristics of farms that contribute to these problems. First, farm businesses take advantage of economies of size as well as utilize technologies which require large capital investments. Second, assets and equipment are difficult to sell quickly and convert into cash. Third, farm ownership, management, and finances are often solely dealt with by the farmer. Fourth, the average age of farmers is increasing. Fifth, most farm families have a unique family value system. Farming is not just a business, but also a special lifestyle. In order to preserve that way of life, many farm families prefer the farm and its assets, especially land, to be passed on from one generation to the next.

Gasson and Errington (1993) examined the process by which family farms are transferred from one generation to the next. Three phases of the intergenerational transfer process were identified. These phases include succession, retirement, and inheritance. Succession is the process by which the managerial control of the farm business assets is transferred to the next generation. Retirement is the phase in which the current manager, typically a member of the older generation, relinquishes managerial control to the younger generation. Finally, inheritance is the process by which the legal ownership of farm business assets, including land, is transferred to the younger generation. Progression through each phase typically occurs gradually. The succession and retirement phases are mirror images, as the younger generation assumes more managerial responsibility, the older generation is giving up managerial responsibility. When business ownership is transferred via inheritance, succession occurs concurrently (Gasson and Errington 1993; Errington 1998).

Errington (1998) identified a "succession ladder" which outlines the various stages of managerial transfer from the older to the younger generation. The first step consists of day-to-day tactical decisions being shared initially by both generations before being transferred to the younger generation. The second step of the succession ladder involves the transfer of long-term strategic planning decisions. The transfer of personnel management decisions is the third step of the succession ladder. The fourth step of the succession ladder includes the transfer of financial management decisions. The fifth step of the succession ladder is the transfer of authority to pay bills. Often referred to as the "control of the purse strings" (Errington 1998), this final step in the succession ladder is often the last decision-making responsibility handed over to the successor. Additionally, this authority may be handed over to the younger generation well after all other business management decisions have been passed down. This could be due to the fact that as long as the older generation feels that they have control over the farm business chequebook, then they still have a significant role in the business.

Farm transfer timing can have a considerable impact on transfer success. Well-timed transfers of management and ownership can promote and preserve family relationships as well as contribute to financial security for both the parents and the younger generation (Kimhi 1994). Kimhi (1994) found that the timing of farm transfers from the parents to the younger generation was ultimately determined by the parents in an effort to maximize welfare of family members. Yet, Anderson and Rosenblatt (1985) found that many farm families do not participate in formal succession planning or discuss succession planning or retirement planning with their children. In many cases, farm families believe that succession will "fall into place" when the time comes (Keating and Little 1997).

## Equality versus justice in farm transfers

The decision of how to best distribute the farm business among successors or heirs is one that must be approached carefully. Often transfer decisions are discussed in terms of fairness. However, fairness is ambiguous and does not mean the same thing to every person. Because of these perception differences, the concept of "fair" is not useful for identifying optimal distribution strategies (Taylor and Norris 2000). A better term is "just" or "justice". Philosophically defined, "justice" means that one gets what one deserves (Schurter and Wilson 2009).

The question of farm business distribution often becomes one of deciding whether to divide the business equally or justly among successors or heirs. Equal division occurs when all successors or heirs receive an approximately equal share in the distribution. Justice in this situation indicates that distributions are based on how much work each potential successor or heir has put into the business. When planning a farm transfer, the primary decisions that the older generation must make include determining which successors should receive a stake in the business and how to divide ownership and management responsibilities among successors in an optimal way (Gasson and Errington 1993).

Taylor and Norris (2000) conducted a study which investigated how perceptions of justice among farm successors impacted the success of the family farm succession transition. The results indicated family communication styles tended to determine whether the farm business was distributed equally or equitably among heirs (Taylor and Norris 2000).

## Transfer of the occupation of farming

In addition to the high proportion of family farms transferred from one generation to another, the transfer of the occupation of farming can also be considered as a form of succession (Fischer and Burton 2014; Lobley, Baker, and Whitehead 2010; Silvasti 2003). Studies have found that farmers are as much as five times more likely to have come from a farming family than children whose families owned and operated other types of family businesses (Blau and Duncan 1967; Laband and Lentz 1983; Keating and Munro 1989). Laband and Lentz (1983) found that farmers often followed a pattern of "occupational inheritance" in which individuals assumed the same occupational role as that of their fathers. Incidence of "occupational inheritance" was found to be particularly high among farmers and other self-employed proprietors (Laband and Lentz 1983).

## 3. Factors Affecting Farm Succession

The transfer of farm business management responsibilities often, although not always, precedes a transfer of farm ownership. Methods by which the younger generation returns to participate in the management responsibilities of a farming business can vary tremendously. Both the farm and successor must be developed over a period of time, and a distinction can be made between possible and prospective successors. Possible successors are assumed to be future successors, but ultimately choose what they wish to do. Probable successors are preparing to take over managerial control of the farm at some point in the future (Chiswell 2014; Fischer and Burton 2014; Gasson and Errington 1993).

For the purposes of this study ''succession'' will refer to the transfer of managerial responsibility of the farm business assets (Gasson and Errington 1993) or the younger generation establishing an occupation in farming on a farm separate from the older generation's farm business. Inheritance, as defined by Gasson and Errington (1993), is the transfer of ownership interests in the family farming business. Although this study does not explicitly look at issues related to inheritance, the concepts of succession and inheritance do work in tandem in certain situations. With inheritance, succession is implied, as the control of the management of farm assets accompanies the ownership control of those assets.

Examination of the motivations for why the younger generation is incorporated into the management activities of the family farm business or undertakes its own farming business requires assessment of several factors. One consideration is the length of time that the family has been involved in the business of farming. Farms that have been owned by the same family for multiple generations may be expected to continue being passed down from generation to generation. Similarly, families which have been involved in farming businesses for several generations may be more likely to have members of the younger generation enter into the occupation of farming (Lobley 2010; Lobley, Baker, and Whitehead 2012; Riley 2009; Riley 2014).

Principal operator age and the length of time that the principal operator has been active in a farm business can significantly impact the decision of when the younger generation chooses to enter into farming (Gasson and Errington 1993). In farming businesses in which the successor(s) comes back to work with the older generation, the principal operator typically is a member of the older generation. However, young successors to the occupation of farming may have their own farm businesses in which they are the principal operator.

The number of potential successors is also a major factor in the decision for the younger generation to join a family farming business or start its own farming business. In cases where multiple potential successors are present, the principal operator must determine how to best allocate managerial responsibilities between each member of the younger generation. There may be instances where there are multiple members of the younger generation, yet all members do not wish to participate in the management activities of the business. Those who do not wish to participate in the farm management activities may want to be compensated in other ways to feel as though they received ''equal'' treatment in comparison to those who are participating in the business. Another situation which can occur is when multiple members of the younger generation wish to become business partners in a farm separate from the older generation's farming operation (Burton and Walford 2005; Cassidy and McGrath 2014).

It is important to examine how the legal business structure may have changed in order to most efficiently and effectively accommodate the younger generation joining the family farming business. Likewise, the legal structure of the younger generation's own farm can significantly impact how financing is obtained for both business startup as well as continuing production activities. Various legal structures have potential advantages and disadvantages that must be assessed in order to determine which is most economically feasible.

In situations where members of the younger generation come back to work in the older generation's farm business, comparison of management activities before and after the inclusion of the younger generation is vital. It is important to determine how much managerial responsibility that the younger generation has assumed and in what areas of the business. Insight into why the younger generation has assumed those particular responsibilities is also essential. Farm businesses started by multiple members of the younger generation should be assessed to determine why management activities were delegated between the business partners as they were.

Finally, evaluation of family involvement in the decision for the younger generation to come back into farming is needed. This includes determination of the level at which other members of the younger generation were involved in the decision-making process, even though they might not have actually become involved in the daily activities. These key elements for determining the motives behind how members of the younger generation started farming businesses or were included in the family farming business are summarized in Figure 1.

## 4. Methods And Procedures

Qualitative research methods were utilized in this study. Diverse varieties of research questions often require equally diverse methods of analysis. Just (2001) advocated the use of research methods other than quantitative approaches. Interest in using qualitative analyses in agribusiness research has been recently increasing. Fischer and Burton (2014) interviewed 22 farm families and concluded that the farm succession process must be natural, given sufficient time, initialized early, and is individual. They asserted that a farm succession 'crisis' is occurring, due to the lack of intergenerational farm transfer in Europe. Chiswell and Lobley (2015) countered Fischer and Burton (2014) by questioning whether there is indeed a lack of succession occurring, and if so, what is the optimal level of succession? In a counter to Chiswell and Lobley (2015), Burton and Fischer (2015) assert that although there is not a succession ''crisis'' in all areas, certain areas of Europe, are very much in need to increased succession. Riley (2014) utilized a joint interview approach to the study of fathers and sons involved in farming in order to gain a better view into the interpersonal relationships among the farming generations. Cassidy and McGrath (2014) used qualitative methods to investigate non-successors points of view. Chiswell and

 

- How long has the farming business been within the family?
- How old is the principal operator?
- How long has the principal operator been active in the farm business?
- How many potential successors plan to join the farm business?

- What was the legal structure of the business before the successor(s) joined?
- Was the legal structure changed to better accommodate the successor(s) joining the business?

- Who was responsible for performing management activities before the successor(s) joined the business?
- Which management activities have been assumed by the successor(s)?
- How was the decision made to put the successor(s) in charge of those particular management activities?

- Were all family members involved in the decision for the successor(s) to join the business?
- Did members of the younger generation who did not wish to participate in the management activities of the business participate in the decision making process to include the successor(s) within the business?
- Were members of the younger generation who did not wish to participate in the management activities of the business compensated in any way when the successor(s) joined the business?
- If members of the younger generation who did not wish to participate in the management activities of the business were compensated in some way, was the compensation approximately "equal" to the amount of management responsibility the successor(s) was granted? If not, why?

**Figure 1:** Factors Affecting Farm Succession Decisions

Wheeler (2016) focused on ethical and safety concerns of female qualitative researchers when performing field research in agriculture.

Interviews were conducted with seven families whose farm businesses were located in the northern and southern high plains of Texas. The interview method allowed for detailed analysis of the similarities and differences among the study sample. Family farm businesses which initially appeared very similar in business structure were found to have significantly divergent methods by which

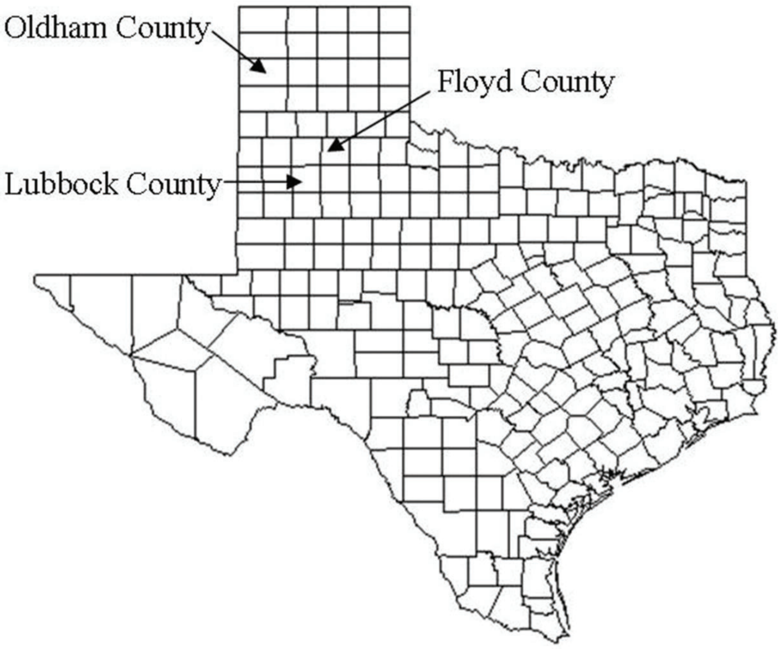


**Figure 2:** Study Region

successors were incorporated into the management activities of the business or obtained their own farming operations.

Potential interviewees for the study sample were identified via contacts within the local agricultural industry. Interviews were conducted with families operating farms in three counties in Texas, Oldham County, Floyd County, and Lubbock County. Location of the counties in which interviewees' farming businesses were based is shown in Figure 2.

Semi-structured interviews were conducted. Interviewees were asked open-ended questions regarding farm structure, farm management activities, changes to farm management activities upon the successor(s) joining the farm business or responsibilities the successor(s) had taken over upon beginning operation of their own farming business, and the family decision-making process when determining how the successor(s) should enter into the farming business or how to assist the successor(s) in acquiring their own farm business.

Interviews were 30 to 45 minutes long, with members of both the older and younger generations participating. The older and younger generations were interviewed concurrently due to ease of recruitment and reduced infringement on participants' time. Members of each generation conveyed that concurrent interviewing was not disruptive, and in fact, was in several cases beneficial, as each generation was able to gain insight into the other generation's decision-making processes. Field notes were taken during interviews. Interviews were also tape recorded. After interview completion, recordings were transcribed into written notes for computational analysis. Qualitative research software was utilized in order to code and identify major themes which were discussed during interviews.

## 5. Results

Analysis revealed six major categories of topics discussed during interviews. These six categories included discussion regarding farm business legal structure and operator demographics, farm business management, family decision-making processes, the younger generation's involvement in farming, farm business transfer and distribution, and other topics. The six major categories were further subdivided into 47 themes which were discussed by the families interviewed. Examples of themes include discussion regarding the number of generations that a family had been involved in farming, management transfer from one generation to the next, and the younger generation's decision to farm as a career. The frequency of themes discussed in interviews was also recorded. For simplicity, interview themes were assigned a number from 1 through 47. The six discussion topic categories, 47 themes, theme numbers, and frequency of theme discussion for all interviews are summarized in Table 1.

Figure 3 depicts the frequency of themes discussed (by theme number) for all interviews and is separated by individual interview.

Figure 4 depicts the amounts that each individual discussion topics and themes were discussed in all interviews. Specific themes discussed in each interview are identified by the appropriate theme number located at the edge of each chart slice. The size of each chart slice indicates the proportion of all interviews that were spent discussing a particular theme.

Each family interviewed had been involved in farming for multiple generations. The number of generations that the families had been involved in farming ranged from two to four. Additionally, multiple families interviewed had more than one generation working in the farm business concurrently.

Farm business organization varied greatly among the families interviewed. Some families incorporated the younger generation into the farming business directly, by restructuring the business organization in order to make the younger generation a partner within the business. In other cases, the younger generation returned to farm work after attending college and/or working in other

 

**Table 1:** Frequency of Interview Themes

| Theme # | Theme Description | Frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Interview: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | All |
| FARM BUSINESS LEGAL STRUCTURE AND OPERATOR DEMOGRAPHICS | | | | | | | | | |
| 1 | *Farm business legal structure* | 8 | 6 | 3 | 10 | 1 | 1 | 3 | 32 |
| 2 | *Family operated multiple farm businesses with different legal structures* | -- | -- | -- | -- | -- | -- | 3 | 3 |
| 3 | *Farm business legal structure changed to simplify farm transfer process* | -- | -- | -- | -- | -- | -- | 2 | 2 |
| 4 | *Farm business principal operator* | 3 | 1 | 4 | 2 | 1 | 2 | 2 | 15 |
| 5 | *Family members involved in farming* | 9 | 4 | 5 | 5 | 1 | 2 | 1 | 27 |
| 6 | *Number of generations family had farmed* | 1 | 1 | 4 | 1 | 2 | 2 | 2 | 13 |
| 7 | *Generations farmed separate businesses but assisted each other as needed* | 4 | 32 | -- | -- | -- | 1 | -- | 37 |
| FARM BUSINESS MANAGEMENT | | | | | | | | | |
| 8 | *OG and YG shared farm equipment* | 2 | 15 | 1 | -- | -- | 2 | 1 | 21 |
| 9 | *Equipment acquisition by each generation* | 5 | 7 | 1 | -- | -- | 1 | 1 | 15 |
| 10 | *Management transfer from one generation to the next* | 5 | 5 | 5 | 14 | -- | 2 | 5 | 36 |
| 11 | *YG provided additional perspective and assessment for farm business* | -- | -- | -- | 7 | -- | -- | -- | 7 |
| 12 | *Management transfer due to individual strengths* | -- | 5 | 1 | 1 | -- | -- | -- | 7 |
| 13 | *Individual(s) responsible for management decisions* | 14 | 20 | 6 | 9 | 7 | 1 | 3 | 60 |
| 14 | *OG retained responsibility for marketing and/or financial management* | -- | -- | 2 | -- | -- | -- | 1 | 3 |
| 15 | *YG allowed to make financial decisions for farm business* | -- | -- | -- | 2 | -- | -- | -- | 2 |
| 16 | *OG trusted YG farm management decisions* | -- | 4 | 1 | 11 | -- | -- | -- | 16 |
| 17 | *Hired labor did not participate in management* | -- | 5 | -- | 3 | -- | -- | -- | 8 |
| 18 | *Importance of communication between generations* | 2 | 7 | -- | 5 | -- | -- | -- | 14 |
| 19 | *Importance of continued farm growth* | -- | 2 | -- | -- | -- | -- | -- | 2 |
| 20 | *Obtainment and utilization of financing* | 5 | 3 | 2 | -- | -- | -- | -- | 10 |
| 21 | *Each generation responsible for financing own farm business* | 2 | 8 | 4 | -- | -- | 1 | -- | 15 |
| 22 | *YG discussed financial decisions for own farm with OG* | 2 | 3 | -- | -- | -- | -- | -- | 5 |
| 23 | *Problems due to OG owners not involved in management trying to manage* | -- | -- | -- | -- | 1 | -- | -- | 1 |
| FAMILY DECISION-MAKING PROCESSES | | | | | | | | | |
| 24 | *Some YG siblings not involved/did not plan to become involved in farm* | 2 | 6 | -- | -- | 1 | -- | -- | 9 |
| 25 | *YG siblings not involved had no input/did not object to others decision to farm* | 5 | 1 | -- | 3 | 7 | -- | -- | 16 |
| 26 | *Other family members not involved in farm had input in others decision to farm* | -- | -- | -- | -- | -- | -- | 1 | 1 |
| YOUNGER GENERATION INVOLVEMENT IN FARMING | | | | | | | | | |
| 27 | *YG decision to farm as a career* | 7 | 14 | 12 | 4 | 2 | -- | -- | 39 |
| 28 | *YG joined as partner/shareholder in OG farm business* | -- | -- | -- | 1 | -- | -- | 2 | 3 |
| 29 | *YG started own farm after working temporarily as hired labor for OG* | 2 | 12 | -- | -- | -- | -- | 3 | 17 |
| 30 | *YG operated own farm business* | 2 | 16 | 10 | -- | 3 | 4 | -- | 35 |
| 31 | *YG began own farm so OG farm was not financially compromised* | 2 | 4 | -- | -- | -- | -- | -- | 6 |
| 32 | *YG rented/tenant farmed land for own farm* | 1 | 6 | 2 | -- | 4 | 1 | -- | 14 |
| 33 | *YG manages part of OG farm* | -- | -- | -- | -- | -- | 2 | -- | 2 |
| 34 | *YG owned land for own farm business* | -- | -- | 2 | -- | -- | -- | -- | 2 |
| 35 | *YG worked for salary in OG farm business* | -- | -- | 3 | -- | -- | -- | -- | 3 |
| 36 | *OG owned land rented/tenant farmed by YG* | -- | -- | -- | -- | 4 | -- | -- | 4 |
| 37 | *YG more comfortable with new technology* | -- | 1 | -- | 3 | 2 | -- | -- | 6 |
| FARM BUSINESS TRANSFER AND DISTRIBUTION | | | | | | | | | |
| 38 | *OG intended to distribute farm business to YG equally* | 2 | 6 | 1 | 8 | 2 | -- | -- | 19 |
| 39 | *OG distributed farm business to YG based on YG contribution to farm* | -- | -- | -- | -- | -- | -- | 5 | 5 |
| 40 | *YG owned farm business split equally among siblings* | -- | -- | 1 | -- | -- | -- | -- | 1 |
| 41 | *Topic of farm transfer sensitive; family would not discuss prior bad experiences* | -- | -- | -- | -- | -- | 2 | -- | 2 |
| 42 | *OG will not discuss/plan for farm transfer* | -- | -- | -- | -- | -- | 2 | -- | 2 |
| 43 | *YG thinks OG should discuss/plan for farm transfer* | -- | -- | -- | -- | -- | 4 | -- | 4 |
| OTHER | | | | | | | | | |
| 44 | *OG retirement considerations* | -- | 3 | 3 | -- | -- | -- | -- | 6 |
| 45 | *OG is phasing out of farming somewhat* | -- | -- | 8 | -- | -- | -- | 1 | 9 |
| 46 | *YG does not think OG will ever completely retire from farming* | -- | -- | 6 | -- | -- | -- | -- | 6 |
| 47 | *Family believed that family farm dynamics were unique to geographic area* | -- | -- | -- | 2 | 2 | -- | -- | 4 |

*Note: YG = Younger Generation; OG = Older Generation.*

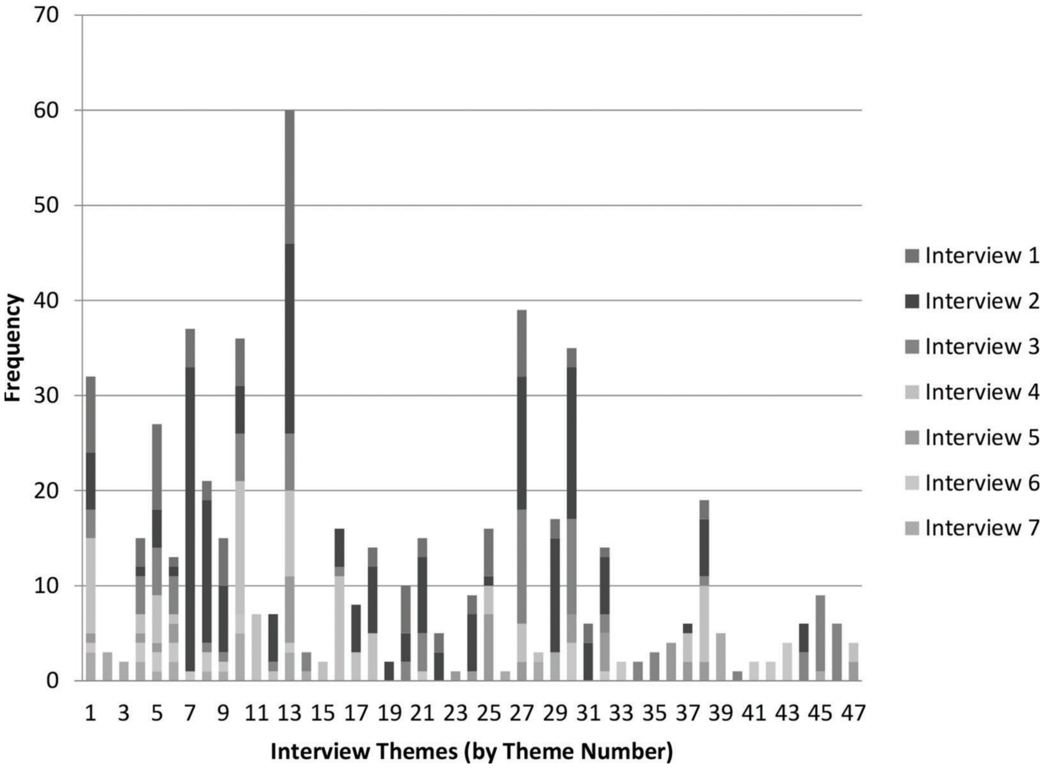


**Figure 3:** Frequency of Interview Themes – All Interviews

non-agricultural occupations. In some instances, the younger generation initially worked for the older generation as a form of hired labour before embarking on a separate farming business venture. A frequent arrangement described was the younger generation leasing farmland from the older generation, while the younger generation was establishing a new farming business. Five families indicated that the younger generation had leased farmland from the older generation as a way to establish the younger generation's new farm business.

Four families also indicated that the younger generation was assisted in starting its own farming business separate from the older generation by the sharing of farm equipment between the older and younger generations. By working out an arrangement on farm equipment purchases, the younger generation had a way to gain access to the necessary equipment, without the burden of being solely financially responsible for large purchases. The gratitude of the younger generation was expressed when discussing the assistance with large equipment purchases: *"They [father and uncle] can make a big purchase, like another cotton stripper or something, but we all still work together, so it's more or less coming to me, too," said one member of the younger generation. (Interview 1, son).*

> *"It allows us to effectively and efficiently utilize the resources we have, so that we don't have multiples of the same equipment, and also allows us to purchase bigger and better machinery,"* said a son who had an equipment partnership with his father. (*Interview 6, son*)

In some cases, farm equipment was simply shared between the generations on their separate businesses. In other cases, equipment partnerships were formed and a detailed accounting was kept of who used certain equipment and when.

The transfer of managerial decision-making varied greatly among interviewed families. In cases where the younger generation had only come back to work with the older generation temporarily before starting a separate business, the transfer of managerial power tended to be minimal. Often the younger generation described the process as working as "hired labour" and indicated that primarily manual labour tasks were performed as opposed to managerial decision making: "*He [son] was a hired employee initially*," one father said about his son who had joined the family farming business. *(Interview 7, father)*

However, in some cases, working for the older generation as hired labour inspired the younger generation to branch out and establish its own farming business. One father and son described how such an arrangement improved both their wellbeing: "*He [son] gets up in the morning and he goes and does his thing, and I go do mine*," the father said. The son jokingly agreed and said "*It's to keep both our sanity*." The son continued, more seriously, discussing how working for his father motivated him to get his own business off the ground: *"It was probably more of a good thing, because that gave me a little more drive to branch off and get my own place going," the son said. (Interview 2, father and son)*

Other situations involved the older and younger generations each tending to some portion of managerial decision-making. In one case, the son operated his own farming business as a sole proprietor, but also operated a joint venture with his father and uncle. While he was solely responsible for the management of his own business, he split management decisions for the joint venture with his father and uncle. *"We work together on it [management of the joint venture]," said the son. (Interview 1, son)*

 

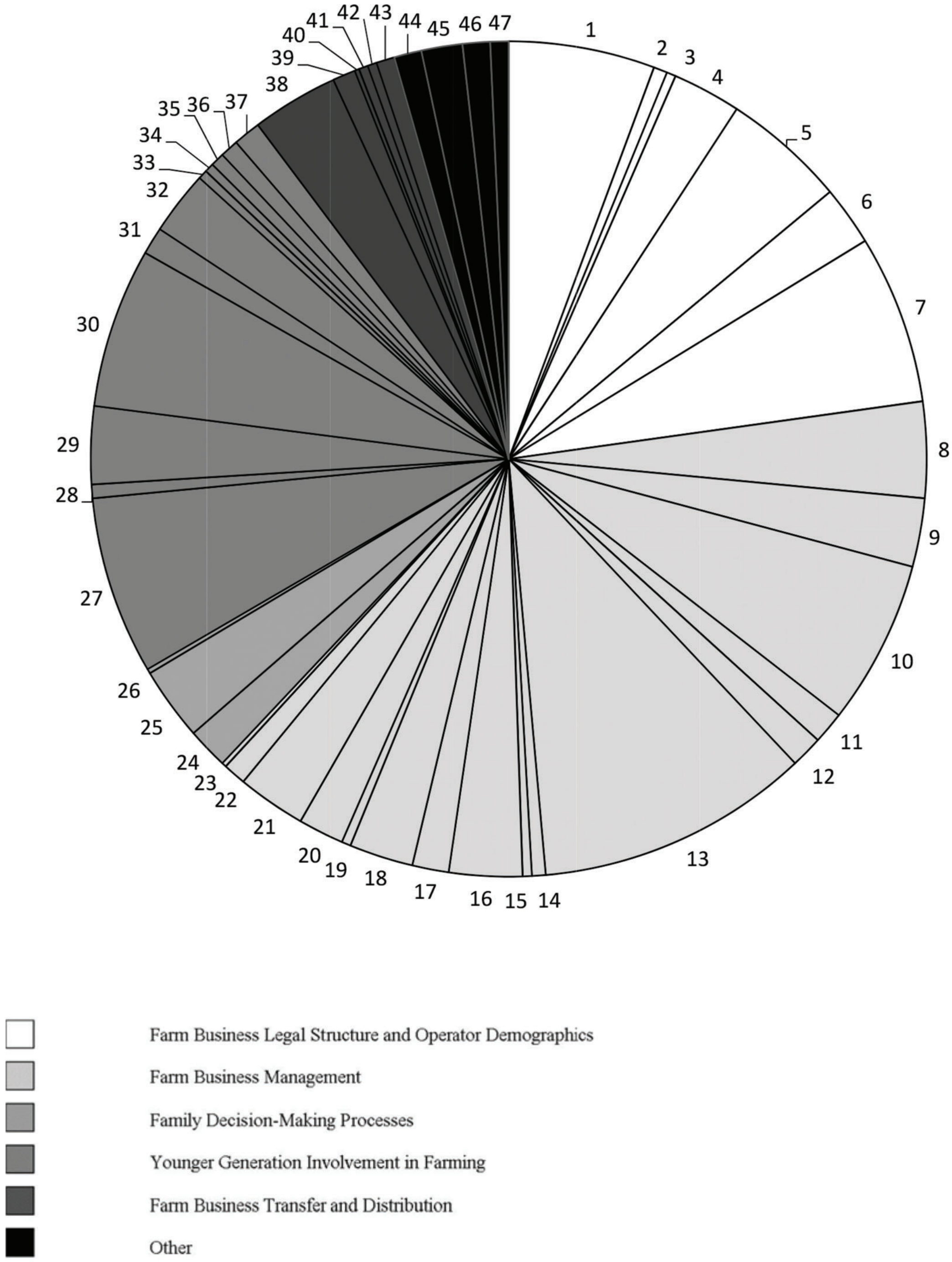


**Figure 4:** Categories and Themes (by Theme Number) for All Interviews

In situations where the older and younger generation each assumed a portion of managerial control, managerial delegation was often dictated by each person's particular strengths in various areas. Often the older generation was well versed in making marketing, banking, and financial decisions, whereas the younger generation was more skilled in production practices, especially practices that implemented extensive technological equipment. This type of arrangement allowed the younger generation to learn not only the technical skills relevant to production, but to also learn by observation how to best manage marketing and financial business decisions. Insight into the distribution of managerial control was highlighted in multiple interviews. "*Dad has all the experience, and I'm gaining the experience,*" said the son. *(Interview 2, son)*

> "*We're [three brothers operating a partnership together] trying to get better at talking to the lenders, but it's tough to learn,*" the eldest brother admitted. "*We're glad dad takes care of it [business and financial decisions] for his business. NRCS [Natural Resources Conservation Service], FSA [Farm Service Agency], insurance, dad takes care of that stuff more,*" he added. *(Interview 3, brother)*

"*A lot of management has just deferred to him [son]*" said a father who now operates his farm business in a partnership with his wife and son. The father jokingly added that he had handed over responsibilities that he [father] was tired of. One unique aspect of this partnership was that the son had access to the farm business chequebook, which is often a responsibility that the older generation retains much longer than other managerial responsibilities. The son attributed this management delegation to clear communication with his father. "*We speak the same language,*" said the son. The son elaborated on how important managerial decisions were usually discussed at length between him and his father: "*We communicate a lot on decisions with the insurance and things like that. It's collaborative. A lot of the spraying stuff I do, kind of handle, and computer stuff, but on important decisions, it's collaborative,*" the son added. *(Interview 4, father and son)*

Incorporating another generation into a farming business also complicated the decision-making process in some cases. When additional managers were added to the business, the decision making process became more complex. "*The decision-making is now a lengthier process due to having more stockholders in the business,*" explained a farmer who operated two farm businesses, a partnership and a corporation, with his father and his son. *(Interview 7, father)*

When discussing the process by which the younger generation became involved in farming, each situation was obviously unique, but some underlying themes emerged from multiple cases. In several situations, the younger generation did not hesitate to report that there was never any question that they would go into farming, whether working with the older generation in the family farming business or embarking on their own farming venture. Each family interviewed had multiple children. In several instances, the child or children that became involved in farming indicated that other siblings were not really consulted when they were deciding to go into the farming business. The decision was generally made by the children and their parents.

> "*I've worked out here my whole life, even when they [sisters] would go work in town or do something different. You know I've been out here the whole time, so they [sisters] knew it was going to happen here [him entering into farming],*" said one young farmer. *(Interview 1, brother)*
>
> "*We always knew we would come back to the farm business,*" said a farmer operating a partnership with his two brothers. He also explained how his father had made the three brothers feel as though they were important elements in the farm business when they were young. "*Dad always made us feel like a part of the business when we were kids. We never felt like hired hands,*" he said. *(Interview 3, brother)*

A son who joined as a partner in his family's farming business explained how he continued to help out his father with the farm as necessary even while he was attending college and working in a non-agricultural occupation: "*We [brother and sister] never really completely left. We'd come back on weekends, and plow, or run the tractor. We left, but not completely removed,*" he explained. *(Interview 4, brother)*

A woman who owned the family farmland discussed how her son came to be the tenant farmer on the family's land: "*The land has always been in the family and has always had a tenant farmer. When my husband retired, he [son] took over it,*" she said. *(Interview 5, mother)*

The future of the farm businesses owned and operated by the families interviewed was as unique and varied as each interview situation studied. Because each family interviewed had multiple children, the decision of how to distribute the farm business management responsibilities and assets during the succession and inheritance processes differed among each family. In all but one case, the family indicated that the children would be or had been compensated in an approximately equal way, regardless of whether each child received an equal portion of the farm business, or whether some were compensated monetarily. One young farmer discussed the process: "*It evened out everywhere. And since then I've been able to help my parents out through some stuff now, too. It's all been paid back*" he said. *(Interview 1, son)*

A son who had joined in a partnership with his father discussed how he and his sister would be compensated approximately equally: "*She [sister] does have a stake in it [the farm business], but that kind of will come out, the way I understand it, you know, if he [dad] retires or an inheritance, basically I won't get much, because my inheritance is the equipment I'm farming with, you know, that's kind of the way my understanding works, but she [sister] definitely gets a fair shake, it's just that it's not immediate,*" he explained. His mother, also a partner in the business, echoed his thoughts: "*Well, and he [son] might get maybe a little more control, I guess you'd say, of the equipment and the land and everything; her [sister] compensation will probably come in a monetary form. So, it's going to even out, but going to be in a little different form,*" she said. *(Interview 4, father, mother, son)* "*For inheritance purposes, they [children] all get equal shares,*" indicated a woman who owned farmland that her son farmed as a tenant farmer. *(Interview 5, mother)*.

Only one family interviewed indicated that distribution of farm management responsibilities and assets would not be spread equally among the children. The principal operator had two farm businesses, a partnership and a corporation, which he ran with his father and his son. He indicated that management responsibilities, as well as stock ownership in the businesses was not equal, but rather proportional to the amount of work that each stakeholder had put into the business: "*The businesses aren't distributed equally. It's by how much each person has put into it,*" he said. *(Interview 7, father)*

Multiple families also discussed how much farming meant to them in terms of planning for retirement and subsequent succession and inheritance. In several cases, the older generation indicated that retirement was still far in the future and they were still very much focused on growing the business. Some members of the younger generation also indicated scepticism regarding whether the older generation would ever completely retire from farming. Finally, in some cases the younger generation admitted that they had not thought much about planning for the succession and inheritance processes, although they probably should. One member of the older generation mentioned, "*We're [the business] not big enough just to stop growing. We have to continue to grow, so that,* *and I'm not near ready to retire, so that is what the goal will be is to continue to grow the operation.*" *(Interview 2, father)*

A farmer who operated a partnership with his brothers jokingly mentioned how his father had a hard time giving up control of his [the father's] farm business: "*Dad says he needs to learn to let go of some of the control, but I don't know if he will,*" the son says. "*It [the farm] gives him [father] a reason to get up in the morning,*" the son concluded *(Interview 3, son)*. One young farmer admitted he probably needed to think about and plan for succession: "*I haven't really thought about any kind of succession, although I probably should*" he said. *(Interview 6, brother)*

## 6. Conclusions

### Succession patterns

This study joins other recent qualitative work on family farm intergenerational transfers, by providing additional insight into the complex family dynamics which occur during transfer planning and implementation. Some findings confirmed those of other recent work, while other findings contradicted. Some families interviewed exhibited traditional methods of succession in which the younger generation was incorporated into the older generation's farming business, such as when the younger generation returned to work in the older generation's farming operation after attending college and/or working in an off-farm occupation. In these situations, the younger generation typically became a partner or stockholder in the family farming business and participated in various management activities. This process confirms Gasson and Errington's (1993) theory of partnerships being the succession pattern of choice in some cases.

Alternatively, some members of the younger generation returned to work briefly for the older generation before embarking on their own farming business venture. In these cases, the younger generation often worked for the older generation primarily as hired labour, typically with little involvement in managerial activities. This phenomenon demonstrated the idea of "occupational inheritance" or succession of the occupation of farming as suggested by Laband and Lenzt (1983) and Lobley, Baker, and Whitehead (2010), rather than direct succession of the younger generation to the older generation's farming business. In several cases observed, the older generation had done this, by way of allowing the younger generation to lease land from the older generation to embark on a farming career. In addition, some families exhibited a combination of each method, where the younger generation co-managed a joint venture farming operation with members of the older generation, while also operating a separate farming business exclusively managed by the younger generation.

### The succession ladder

The idea of the succession ladder, as proposed by Errington (1998), was confirmed in some cases studied, and contradicted in others. Several families interviewed indicated that the younger generation had assumed management activities lower on the succession ladder first, such as day-to-day and strategic management decisions. This left the management decisions higher up the succession ladder, such as marketing and financial decisions, as the responsibility of the older generation. However, in some cases studied, the succession ladder did not appear to hold. In one case, the son had recently joined a partnership with his mother and father. While the son did attend to management tasks lower on the succession ladder, he also had access to the farm business chequebook and had the ability to make significant financial decisions, which is often one of the last managerial tasks that the older generation gives up to the younger generation. Thus, this case was unusual in this regard. Additionally, in another case, the son had joined as a partner and stockholder in two family farming businesses. Again, the son attended to managerial tasks lower on the succession ladder, yet also had the responsibility of managing other farm personnel, which is typically a management activity that the older generation retains for a longer period of time. While the son managed the farm personnel, he did not have the authority to make major financial decisions for the businesses. Finally, cases examined in which the younger generation had branched off from the older generation's farm business to start a separate venture did not exhibit the classic succession ladder method of managerial transfer. In these cases, the younger generation assumed full responsibility for all managerial decision-making for their business, although it was reported that members of the older generation were often solicited for help or advice during various decision-making processes.

Educational background of the younger generation may have influenced the older generations' decisions when assigning management responsibilities. In all but one interview, members of the younger generation were either attending or had graduated from college. The older generation may have drawn increased confidence regarding the younger generations' decision-making capabilities due to their educational background. Additional research into the theory of the succession ladder is warranted in order to more fully understand the thought process of each generation when determining which managerial activities that the younger generation will assume when working in a farming business.

### Distribution of family farm businesses

Each farm family interviewed had multiple children. All but one family indicated that the farm business would be transferred in approximately equal portions to the children in some way. While several families indicated that children who were not active in the management or operation of the farm business would nevertheless receive an equal share, they admitted that the shares given to non-participating children would likely be in a form other than farmland or farm assets outright. In most cases, the family expected non-participating children to be compensated in some monetary form, either through an outright monetary gift or a buy-out arrangement. Because these families wanted to compensate children equally, this behaviour points toward an exchange motivation for the intergenerational transfer of the farm. Exchange motivation is characterized by the older generation desiring to compensate children equally.

The one case in which the older generation indicated that the intergenerational transfer of the farm business would not be distributed equally suggests an altruistic motivation for the transfer. In this case, the principal operator of the farm business indicated that each family member would be compensated in accordance to work put into the business. This method of distribution can be interpreted as one of justice, rather than equality.

### Study limitations and future work

A limitation of this study is that the interviews were conducted in a geographically small area. Also, because the research process was qualitative in nature, the sample size for the study was small, although small sample sizes are typical for this type of research method.

Future work will consist of continued interviews and data collection with additional farm families undergoing farm succession. In addition to more data collection in the current study region, additional data collection from other geographic regions will be conducted. Also, interviews with families operating a greater variety of farm and ranch business will be conducted in order to examine similarities and differences in the succession process which may vary by commodity type.

This study provides a unique view into the inner dynamics of family farm succession planning decisions. The ability to examine succession decision-making processes at the individual family level presents new insight into the motivations for families to engage in farming as a profession and subsequently pass that desire on to the next generation. Enhanced knowledge of these dynamics will allow business and financial planning professionals to more accurately address family and business concerns when assisting with the succession planning process.

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REFEREED ARTICLE

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# Planned intentions versus actual behaviour: assessing the reliability of intention surveys in predicting farmers' production levels post decoupling

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**ABSTRACT**

This paper assesses the reliability of intentions surveys in accurately predicting farmers' production decisions following decoupling. Two samples of Irish cattle and sheep farms that participated in intentions surveys in 2004 and 2006, asked about their intended production 3 years hence (2007 and 2009), are revisited and their subsequent production decisions examined. Farmers were questioned about their production plans post decoupling and their subsequent production decisions were also observed. The analysis reveals that on aggregate farmers' production intentions were more accurate in the first than the second survey, i.e. the one conducted before decoupling was introduced. The second survey tended to be characterised by optimism where farmers were more likely to overestimate their future production levels. At an individual level only about half of all respondents acted according to their earlier stated intentions. The majority of the remainder tended to be optimistic, i.e. over estimating their future production levels. Farms are classified into three groups; those that are accurate, those initially overestimating their future production (optimistic) and those underestimating their future production (pessimistic). The multinomial logit model suggests that for the most part the intention-behaviour gap relating to production intentions and behaviour post decoupling was influenced by very few farm and farmer characteristics that were available through the FADN database.

**KEYWORDS:** Decoupling; Intentions Surveys; Multinomial Logit model

## 1. Introduction

Since its inception, the Common Agricultural Policy (CAP) has been subject to almost continual reform, Hennessy et al (2014). Policy analysis at both the ex-ante and ex-post stages is an important part of this highly complex reform process. Indeed, on-going and ex-post policy evaluation is a key element of the latest 2013 reform of the CAP in the form of the Common Monitoring and Evaluation Framework, (European Union, 2015). Ex-ante policy evaluation, typically occurring at the policy proposal stage, is an important means of informing policy negotiators about the likely implications of a proposal. Such ex-ante analyses are usually based on statistical and economic models; these models and their use in CAP analysis are discussed in Ciaian et al (2013). However, when policy proposals represent a radical departure from the past, such models are less useful as they are based on data relating to a different policy regime as outlined in the seminal paper by Lucas (1976). In such cases, many policy studies, as reviewed below, have supplemented or substituted their economic models with farmer intention based surveys to assess how farmers may react to policy reform.

The 2005 reform of the Common Agricultural Policy introduced the decoupling of direct payments, meaning that farmers would receive direct income support regardless of their production levels. This was a radical departure from the previous regime which linked such support to the production of crops and livestock products and as such presented a significant challenge to those involved in policy analysis and the policy negotiation process. At this time a number of policy analysts used intentions surveys to assist in predictions of the impact of decoupling on production decisions. Bougherara and Latruffe (2010) provide a comprehensive review of such studies that were conducted across the EU around the time of the introduction of decoupling, these include; Latruffe and Davidova (2007), Douarin et al. (2007), Tranter et al. (2007) Genius et al. (2008) and Gallerani and Gomez y Paloma (2008), among others. Despite the widespread use of intentions survey data in predicting the impact of

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policy reform, relatively little empirical research has been conducted on the reliability of such data (Lobley and Butler, 2010). The objective of this paper is to review the use and assess the reliability of farmer intention surveys in correctly predicting the impact of a policy reform.

## 2. Background

### Inconsistencies between intentions and behaviour

The theory of reasoned action (TRA) (Ajzen and Fishbein 1980) and the theory of planned behaviour (TBA) (Ajzen 1985) provide useful frameworks for predicting and understanding behaviour, which state that a person's intention to perform a behaviour is the most important predictor of performance. Furthermore, these theories state that constructs such as attitudes, subjective norms and perceived behavioural control all play important roles in formulating intentions. Sheeran (2002) cites examples as to how these constructs of attitudes, subjective norms and perceived behavioural control account for variability in intentions, yet there still appears to be '*less impressive*' (p. 724) predictive accuracy evident from these theories. A number of seminal agricultural economics papers explored this issue by looking at the accuracy of intentions surveys or the magnitude of the so called "intention-behaviour gap". Thomson and Tansey (1982) were among the first to point out the weaknesses of intentions surveys in farming and a recent, comprehensive review of the extensive literature that has emerged on this topic since then is available from Lefebvre et al (2014). The afore mentioned literature outlines various reasons as to why a discrepancy between intention and actual behaviour might exist:

*Timing bias:* occurs when the current economic environment may overly influence farmers' views of the future and/or too little information is available at the time of the survey to make an informed decision. Sheeran (2002) also refers to this as temporal stability and defines the same as '…. *the extent to which an attitude remains unchanged over time regardless of whether it is challenged*' (p. 725). Horowitz (1992) also referred to this issue as 'intertemporal inconsistency'.

*Negligence bias:* occurs when too little time is devoted to answering the questions or respondents feel obliged to provide a response to an issue they have not yet considered.

*Manipulation bias:* occurs when respondents are trying to influence an outcome through their answers, i.e. if they believe their views on a policy option may affect the final policy selected by government.

*Sampling bias:* this may arise where the sample only reflects larger or more efficient farms and where the sample fails to include potential new entrants. Vare et al., (2005) also refers to the issue of actual behaviour being attributed to a number of individuals rather than just the one individual answering the question who may not always have all the information.

The above issues may lead to some inconsistencies between intentions and actual behaviour, what has become known as the "intention-behaviour gap". There are two possible sources of this gap: errors of commission, when a respondent states they will do something but they fail to do so; and errors of omission, when a respondent does not state they will execute a particular action but they actually do so (Fujii and Garling, 2003). An important question is whether the intention-behaviour gap, which is not explained via the theories of TRA and TBA outlined above, can be further explained by some systematic factors (Wong and Sheth 1985). Vare et al., (2005) provided a rationale as to why an understanding of the relationship between systematic factors and intention-behaviour gap was of importance to the reliability of intentions surveys. Firstly, if the intention-behaviour gap happens randomly then the reliability of intention measures is reduced due to a random measurement error. Secondly, if a significant relationship is found between the intention behaviour gap and farm and family characteristics, the results of econometric models based on intentions would be biased if account of these systematic variables is not considered.

A number of studies have attempted to quantify the effectiveness of intentions surveys retrospectively. For example, Thomson and Tansey (1982) revisited an earlier intentions survey and their results showed that only between one-third and one-half of the respondents acted in accordance with their stated intentions. Further, they also observed that one fifth of the farmer's behaviour was in complete conflict with their stated intentions. Vare et al. (2005) revisited a sample of farms that had earlier revealed their succession plans. They found that the majority of farms had behaved in accordance with their plans but that the discrepancy between intention and actual behaviour, where it existed, was significantly related to very few farm and farmer variables, with age representing the most significant explanatory variable significantly related to the farm operator's age, with older farmers being less likely to behave as stated. Lefebvre et al. (2014) also revisited an earlier intentions survey to assess its accuracy. They found that nearly three quarters of farmers' behaved consistent with their intentions and concluded that stated intentions are a good predictor of actions even in a rapidly evolving context.

### Possible Impacts of Decoupling

Economic theory suggests that if coupled subsidies are replaced with payments that are totally decoupled from production, then production should fall to a level that would exist without any subsidies. It follows that production on farms making a market-based loss should fall substantially post decoupling unless significant cost management or efficiency gains can be achieved and production can yield a market-based profit. With a significant number of Irish beef and cereal farmers making a market-based loss, we should expect to see aggregate production of beef and cereals in Ireland falling substantially as a result of decoupling.

As decoupling was an unprecedented policy change in the EU context, historical data provided little indication of the changes decoupling may have engendered. However, there was much literature at the time which debated whether or not the policy represented a fully decoupled one. Swinbank and Tranter (2005) concluded that the retention of the link between the payment and land farmed weakened the EU's argument that the payments were truly decoupled. Furthermore, Burfisher and Hopkins (2003), showed that even fully decoupled payments have a production inducing effect as they

**Table 1:** Stated Intentions and Actual Behaviour

| Stated Intention | Behaviour | Label | No. farms (2004) | No. farms (2006) |
|---|---|---|---|---|
| Expand (2004 n=137) (2006 n= 247) | Expand | Accurate | 78 | 90 |
| | No Change* | Optimistic | 23 | 34 |
| | Contracted | Optimistic | 36 | 123 |
| No Change (2004 n=159) (2006 n=173) | Expand | Pessimistic | 55 | 31 |
| | No Change | Accurate | 33 | 44 |
| | Contracted | Optimistic | 71 | 98 |
| Contract (2004 n=230) 33 (2006 n=259) | Expand | Pessimistic | 63 | 42 |
| | No Change | Pessimistic | 27 | 20 |
| | Contracted | Accurate | 140 | 197 |

**production levels within 10% of the 2004 level are considered as "no change"*

impact on farmers' exposure to economic risk, their access to capital and their expectations about the criteria for future payments (i.e. that future payments could be related to current or future levels of production).

To provide some insight into farmers' production decisions in a decoupled environment in an Irish context, Hennessy and Thorne (2005) examined Irish farmers' intended production plans following the decoupling of direct payments from production. Using data from an intentions survey on farmers' production plans, they concluded that a considerable number of farmers planned to use their decoupled payments to continue or expand economically non-viable production post decoupling. Up to seven years of data are now available on the actual output on the majority of the farms that participated in the 2005 survey. In order to assess the reliability of intentions surveys, we revisit this data to compare the actual production decision to the intentions.

## Data and Methods

Research on stated intentions-behaviour gap is made difficult from a practical perspective because it requires a constant sample. Most surveys protect the anonymity of respondents, which make it difficult to revisit and interview them a few years later, (Lefebvre et al. 2014). The Teagasc National Farm Survey (NFS) has been conducted annually by Teagasc since 1972, being operated as part of the Farm Accountancy Data Network (FADN), fulfilling Ireland's statutory obligation for the provision of data on farm output, costs and income to the European Commission. Each year a random stratified nationally representative sample of approximately 1,100 farms is selected and a weighting factor is assigned to each farm so that the results can be aggregated to be representative of the national population of farms by farm system and farm size. In addition to the FADN dataset, the NFS also occasionally collects additional data on farmers' intentions, like the data used in this paper and in Hennessy and Thorne (2005) and Vare et al. (2005). In 2004 a sample of 1,050 farmers completed a survey about their production intentions in 2007, i.e. post decoupling. 803 of these farms were still members of the survey in 2007 and hence it is possible to compare their actual production decisions with their intentions. Although this survey was conducted for all farm types, the analysis has been confined to cattle and sheep farms. Dairy farms were not examined as they lack the flexibility to substantially change their production levels because of the milk quota system, and crop farms were excluded because of the complexity of multiple crop mixes on farms.

Data are available on 526 cattle and sheep farms in both the 2004 intentions survey and the 2007 survey of actual production. In 2004 farmers indicated the number of suckler beef cows and ewes they intended to stock in 2007, while the 2007 NFS farm data records the actual number of animals stocked on the farm. A further production intentions survey was conducted in 2006 and farmers were questioned again about their future production plans for 2009. A sample of 679 cattle and sheep farmers participated in both the intentions survey in 2006 and the full NFS survey in 2009. Hence it is possible to compare their intentions and their actual behaviour across two time periods[3].

Table 1 contains data on the number of farmers indicating that they would expand, contract or maintain their animal numbers unchanged in both the 2004 and 2006 surveys. To examine accuracy at the individual farm level, farms are classified on the basis of how accurately their behaviour reflected their earlier stated intentions. In Table 1 farmers are classified as Accurate, Optimistic or Pessimistic. Farmers are (i) Accurate, if their animal numbers were within 10 percent of their stated intentions, (ii) Pessimistic if their actual animal numbers were at least 10 percent higher than their stated intentions and (iii) Optimistic, if their actual animal numbers were at least 10 percent lower than their stated intentions.

The largest distinct group of respondents stated intentions to contract production levels in both the 2004 and 2006 survey, with 44 percent and 38 percent of farmers interviewed in 2004 and 2006 respectively stating that they planned to decrease production. Twenty-six percent of respondents, 137 farmers, interviewed in 2004 indicated that they would expand production by 2007, while 36 percent (n = 247) interviewed in 2006 said they would expand production by 2009. It is interesting that even after decoupling was introduced, in effect reducing the economic return to stocking suckler cows and rams, that the percent of farmers planning to increase production increased and the number planning to contract production declined. These survey results were in conflict with the expected effects of a truly decoupled policy (as outlined in the literature review).

[3] It is important to note that both surveys of intentions and subsequent behaviours were examined independently of each other in subsequent analysis. Hence, the possible impact of inter-temporal inconsistency was dealt with separately in subsequent analysis.

 

**Table 2:** Farm Types based on intention-behaviour gap

| | Accurate | Optimistic | Pessimistic |
|---|---|---|---|
| Number of Farms - 2004 (percentage) | 251 48% | 130 25% | 145 28% |
| Number of Farms - 2006 (percentage) | 331 49% | 255 38% | 93 14% |

When the intentions data collected in 2004 are aggregated using the individual farm aggregation factors, the data suggests that the farmers surveyed in 2004 planned to increase suckler cow numbers by 3 percent over the subsequent three years up to 2007 but when the actual production data for 2007 are examined, the results show that numbers actually increased by just 1 percent, so while the direction of change was correct, the magnitude was slightly less than intentions predicted. In relation to ewe numbers, farmers stated that they would contract numbers by 6 percent on aggregate but numbers actually fell by 8 percent. For both ewe and suckler cow numbers it can be concluded that the intentions surveys were reasonably accurate predictors of production levels at an aggregate level. However, it also interesting, and probably more interesting, to consider how accurate the surveys were at the individual farmer level.

Of those indicating they would expand production, almost 57 percent, that is 78 farmers, were accurate in the 2004 survey but only 37 percent were accurate in the 2006 survey. Alternatively, of those indicating that they would contract production, almost 61 percent were accurate in the 2004 survey and 76 percent in the 2006 survey.

Table 2 presents the total number of farmers that were Accurate, Pessimistic or Optimistic across the two surveys. About half of all farmers are classified as Accurate in the two periods. In 2004 the remaining ''inaccurate'' farmers are split almost equally between Optimistic and Pessimistic. However, by 2006 farmers in this ''inaccurate'' category were more likely to be Optimistic. Given that the intentions survey was a reliable indicator of the future in about half of all cases this suggests quite a considerable intention-behaviour gap. It is interesting, and indeed possible with this dataset to address the question raised by Wong and Sheth (1985) as to whether this intention-behaviour gap is affected by some systematic factors. This is a hypothesis we can test by comparing the characteristics of the 3 farm groups (identified in Table 2) and subsequently examined in the econometric model outline in the results section.

## Explanatory Variables

While the literature on the accuracy of farmer intentions is relatively thin, the few studies that do examine the topic suggest that a number of factors available from within the panel data might prove worthy of examination as potential explanatory variables for the intention-behaviour gap. Specific farm variables such as farm size, livestock units, farm system, labour units, the farmer's age and contact with extension agents are hypothesized to influence the intention–behaviour gap. For example, Bagozzi and Yi (1989) suggested that well-formed intentions exhibit greater temporal stability than poorly formed intentions. Hence, it is hypothesized that more educated farmers that are in contact with extension agents may have more informed intentions. Lefebvre et al. (2014) found that the probability of observing an intention-behaviour gap, specifically errors of commission relating to investment in land, significantly increased with farm size and debt to asset ratio. Furthermore, they also concluded that it is important to explore the impact of the farmer's life cycle stage (age and presence of a successor) on the intention-behaviour gap.

Vare et al. (2005) found farmer's age to be statistically significant in the specific example of the reliability of farmers' intentions in accurately predicting farm succession. Vare et al distinguish between what they call ''type II errors'' where succession was planned but did not occur and ''type I errors'' where succession was not planned but actually occurred. They found that the 'type II error' first increases with the farm operator's age, reaches a maximum and then decreases again. While ''type I errors'' increase with the farmer's age, i.e. the older the farmer gets the more likely an unplanned succession occurs.

Finally, economic variables, such as gross margin, intensity of production, farm income and reliance on subsidies are typically used to explain behaviour (Lefebvre et al. 2014). Based on the assumption that decoupled payments are viewed by the farm operator as truly decoupled from production, it is reasonable to expect that farm economic variables could potentially affect intentions and behaviour in the presence of a decoupled policy environment. It is important to remember the caveats surrounding whether or not the policy introduced by the EU was in fact a truly decoupled policy as outlined in the background section above. Furthermore, it is important to remember that expectations regarding the future financial situation of the farm, which is likely to vary from individual to individual is also very important. However, this is beyond the data available in the dataset[4].

Table 3 presents summary statistics for these 3 farm groups and compares them to the full sample. The summary statistics suggest that Optimistic farmers tend to be slightly smaller with lower farm income than the Accurate and Pessimistic farmers on average. The productivity levels of Optimistic farmers, as measured by gross output per hectare, are lower than the other two groups. The lower levels of profitability of the Optimistic farmers are also evident from the cattle gross margin per hectare statistic, but interestingly not the case for

[4] Many other factors other than those observed within the NFS dataset could potentially impact on the intentions-behaviour gap. However, it is not the intention of this study to empirically examine all the different explanations for the intentions-behaviour gap identified in this research. This would go beyond the scope of the paper and could not be done without much additional variables and experimental evidence. The final choice of variables to be included in the two multinomial logit models was made partly on the basis of log-likelihood comparisons between different models.

**Table 3:** Summary Statistics for Farm Groups for 2006

| Variables | Accurate | Optimistic | Pessimistic | All |
|---|---|---|---|---|
| | Mean Values | | | |
| Farm Size – owned & rented (hectares) | 50 | 43 | 59 | 49 |
| Farm Income (€) | 20,450 | 17,350 | 27,950 | 20,315 |
| Livestock Numbers (in Livestock Units) | 87 | 60 | 74 | 75 |
| Specialist cattle rearing (% of farms) | 45 | 42 | 12 | 39 |
| Intensity (Gross output €/Ha) | 1220 | 1110 | 1280 | 1,190 |
| Cattle Gross Margin per hectare | 240 | 200 | 215 | 220 |
| Sheep Gross Margin per hectare | 330 | 375 | 420 | 360 |
| Reliance on Subsidies (% of output) | 44 | 48 | 42 | 45 |
| Farmer's Age | 51 | 48 | 53 | 50 |
| Farmer has off-farm job (% of farms) | 31 | 35 | 25 | 32 |
| Total Family Labour Units | 1.12 | 0.97 | 1.20 | 1.07 |
| Extension contact (% of farms) | 54 | 51 | 63 | 54 |

**Table 4:** Multinomial Logit model of Intentions

| Variable‡ | Expanders | Contractors |
|---|---|---|
| Whole Farm Gross Margin per Hectare | 0.0001 (0.33) | -0.001 (0.37) |
| Reliance on Subsidies | 0.84 (1.3) | -0.76 (1.13) |
| Farmer's Age | -0.027 (3.27)*** | -0.009 (1.08) |
| Farmer has an off-farm job | -0.03 (0.25) | 0.002 (0.02) |
| Constant | 0.812 | 0.398 |
| LR chi2(8) = 13.99<br>Log likelihood = -526.46241 | Prob > chi2 = 0.0821<br>Pseudo R2 = 0.0131 | |

****Significant at the 1% level* ‡ *- t statistic in parentheses*

the sheep gross margin per hectare statistic. In general, Optimistic farmers tend to be younger and are more likely to have an off-farm job than the other two groups. The rate of off-farm employment is far lower for the Pessimistic farmers than the average. On average, Pessimistic farmers are more likely to have contact with an extension officer than either of the other two groups.

Two multinomial logit models are estimated. The first model is used to examine the characteristics of the farmers who said they would maintain, expand or contract animal numbers. The second model is used to test whether the intention-behaviour gap is a random error or whether it is systematically influenced by a limited number of factors for which data were collected. This is achieved by using the multinomial logit model to examine the characteristics of the Accurate, Pessimistic and Optimistic farmer groups. Appendix I provides further detail on the rationale for the choice and specification of the multinomial logit model approach.

## 3. Results

Table 4 presents the results of the multinomial logit model of farmers' intentions. Farmers that said they would expand or contract are compared to the reference category, i.e. those that said they would maintain animal numbers at current levels. Despite the rationale provided in the methods section above, as to hypothesized relationship between the specified variables and the intention-behaviour gap, very few variables available in the dataset are found to statistically significantly affect a farmer's plan to expand, contract or increase production in the next three years. All of the variables described in Table 3 are included in the initial model specifications and even following a stepwise approach the levels of significance are still very low[5].

Farmers' age is the only variable significantly affecting the intention to expand or contract animal numbers relative to the intention to maintain animal numbers at current levels. Farmers planning to expand animal numbers tend to be younger than those planning to maintain production levels, with each additional year reducing the probability of expanding, relative to maintaining numbers. The profitability indicators are not significant, although the gross margin per hectare coefficients do have the expected signs, positive for expanders and negative for contractors. The lack of significance suggests that a farmer's current profitability level has no statistically significant effect on the intention to maintain, increase or contract animal numbers.

Table 5 presents the results of the multinomial logit model of the accuracy of farmers' intentions. Farmers that were classified as Optimistic or Pessimistic are compared to those that were accurate in their intentions.

As can be seen not many of the variables are significantly associated with the probability of a farmer being Optimistic or Pessimistic relative to being Accurate. Farmers with a greater reliance on subsidies have a higher probability of being Optimistic than Accurate, i.e., those with a higher reliance on subsidies were more likely to overestimate their future production plans in the intentions survey. The profitability variable, gross margin per hectare, is significant and negative for the Pessimistic farmers, suggesting that a lower profit per hectare increases the probability of being Pessimistic

[5] Not all variables represented in Table 3 appear in the final specification of the multinomial logit models outlined in Table 4 and 5 due to the stepwise regression process.

 

**Table 5:** Multinomial Logit model of the Accuracy of Intentions: comparing optimistic and pessimistic farmers to those who were accurate

| Variable‡ | Optimistic | Pessimistic |
|---|---|---|
| Whole Farm Gross Margin per Hectare | -0.002 (0.54) | -0.001 (1.69)* |
| Reliance on Subsidies | 1.31 (2.09)** | -0.38 (0.44) |
| Farmer's Age | 0.007 (1.02) | 0.005 (0.47) |
| Farmer has an off-farm job | -0.131 (1.15) | 0.277 (1.55) |
| Contact with an extension officer | 0.085 (0.45) | -0.049 (0.18) |
| Cattle Specialist | 0.024 (0.12) | 0.221 (0.73) |
| Constant | -0.82 | -1.91 |
| LR chi2(12) = 26.44<br>Log likelihood = -541.03151 | Prob > chi2 = 0.0093<br>Pseudo R2 = 0.0239 | |

*Significant at the 10% level, ** Significant at the 5% level. ‡ - t statistic in parentheses

rather than Accurate. The fact that general farm and farmer characteristics such as farmer's age, farm size and system of production are not significant suggests that for the most part, the intention-behaviour gap is not explained by many variables available in the main NFS dataset. a random error.

## 4. Conclusions

Despite the literature on the weaknesses of intention surveys, many studies still revert to such survey methods to predict future farmer behaviour, given that better alternatives often do not exist. Intentions surveys are especially popular in times of unprecedented policy changes, as previous production data provide little insight into how farmers are likely to behave under a new policy regime. It was in this context that quite a number of agricultural economic studies used intention surveys data to predict how farmers might react to the decoupling of direct payments from production in the early to mid-2000s.

The aim of this paper was to revisit one such study, and with the benefit of hindsight and a balanced panel of farms, to ascertain the accuracy of the intentions survey on farmers' production plans post decoupling. The results suggest that the surveys were reasonably accurate in predicting the total change to animal numbers at an aggregate level. However, when individual farmer's responses were examined, the survey only proved accurate in about half of all cases. The results showed that a large proportion of farmers are likely to overestimate their future production plans, i.e. be optimistic. Given the wide range of results reported in the literature in relation to intention-behaviour gaps, with some references citing accuracy rates as low as one third and others citing accuracy rates as high as three quarters, the findings of this research with nearly 50 percent of farmers classified as Accurate, is not out of line with previous research.

A question that is frequently raised in such evaluations is whether the intention-behaviour gap can be explained by some personal or situational characteristics of the respondents. If so, then information about the effect of personal and situational characteristics could be used to improve the accuracy of intentions surveys either through better sample selection and/or some informed manipulation of the results. A detailed examination of the characteristics of the farmers participating in the survey did not reveal many statistically significant factors associated with the probability of being accurate/or not in the intentions survey. Therefore, the results of this study suggest that the intention-behaviour gap is not well explained by the set of variables currently available in the NFS dataset.

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## Appendix

Two multinomial logit models are estimated. The first model is used to examine the characteristics of the farmers who said they would maintain, expand or contract animal numbers. The second model is used to test whether the intention-behaviour gap is a random error or whether it is systematically influenced by certain factors. This is achieved by using the multinomial logit model to examine the characteristics of the Accurate, Pessimistic and Optimistic farm groups.

Since there are multiple choices and particular interest lies in the individual effects of explanatory variables on each outcome in the two models, the behaviour of farmers is modelled using a multinomial logit framework. This is an extension of the binary logit model where the unordered response variable has more than two responses.

The outcome variables y can take on the values $j$ = 1, 2, … $J$ with $J$ being a positive integer. In particular, the models explain the probability of a base category, maintaining production (model 1) or accuracy of production intention (model 2) (j = 1), against other categories of responses (j =2) (j=3) i.e. expand or contract production (mode 1) and pessimistic or optimistic intention versus actual outcomes (model 2). The determinants associated with each category can be contrasted with the base category, which is maintaining production (model 1) or accuracy of production intention (model 2). The interest lies in how ceteris paribus changes in the elements of x affect the response probabilities, $P(y_i = j|x)$, j = 1,2,…J (Wooldridge, 2010). The probability of the categories is determined by the following equation:

$$P(y_i = k|x_i) = \frac{\exp(\beta_k x_i)}{\sum_{j=1}^{J} \exp(\beta_j x_i)}, j = 1, 2, \ldots, J, \tag{1}$$

where k is one of the j subgroups and $P(y_i = k)$ is the probability that the $i^{th}$ farmer belongs to subgroup k and $x_i$ describes farm and farmer characteristics. In order to identify the model, constraints must be imposed. A common approach is to assume that $\beta_1 = 0$ (Long, 1997). This normalization makes it possible to identify the coefficients relative to the base outcome. Applying the constraint, the model can be written as:

$$P(y_i = 1|x_i) = \frac{1}{1 + \sum_{j=2}^{J} \exp(\beta_j x_i)} \tag{2}$$

The multinomial logit model is estimated using maximum likelihood estimation techniques (Long, 1997).

Coefficients are interpreted using the relative risk ratios, which is the relative probability of $y_i = k$, for $k >$ 1 to the base category.

$$\frac{P(y=k)}{P(y=2)} = \exp\left(\beta_j x_i\right), \text{for } k > 1. \tag{3}$$

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# Farmer attitudes to cross-holding agri-environment schemes and their implications for Countryside Stewardship

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**ABSTRACT**

A literature review and on-line consultation (of 122 respondents from across the UK) revealed farmers' perspectives of cross-holding agri-environment schemes (AES). The main concerns raised included; a culture of independent working, lack of existing farmer networks, the validity of farmer-farmer contracts, inadequate financial compensation, the need for third party support, farmers' lack of knowledge of the environmental benefits of AES, and the scheme's "small print". The consultation added the following concerns; the need to offer "collaborative" and "coordinated" environmental management options, the belief that neighbours would not make willing or suitable collaborators, and possible facilitation of the spread of pest and diseases, including non-native invasive species. It uses these research findings to identify which of these concerns have been taken into account in the design of Countryside Stewardship (CS) the recently introduce replacement in England of the Environmental Stewardship Scheme. Suggested changes that may increase CS's effectiveness in enhancing ecological networks include; provision of up-front financial support to farmer-group applications, allowing existing AES agreements to end before their due dates, and removing restrictions on the use of the Capital Grants element. Offering additional resource-based incentives to farmer-group applicants, such as reducing the area of land entered into "greening", can be justified if the expected environmental benefits from cross-holding collective action do materialise.

**KEYWORDS:** Countryside Stewardship; Mid Tier; landscape scale; agri-environment scheme; collaboration

## 1. Introduction

The first environmental scheme in England to financially compensate farmers for loss of income associated with changes to farming practices designed to benefit the natural environment was the Exmoor Management Agreement Scheme (Lobley and Winter 2009). Introduced in 1979, it became the blueprint for compensation arrangements under the UK's Wildlife and Countryside Act (1981) and, by extension, for European agri-environment schemes (AES), under EEC Regulation 797/85 and 2078/92 (Lobley *et al.* 2005). The initial AES have evolved to reflect experiences gained, changing environmental concerns and new understandings of ecological systems and networks (Cooper *et al.* 2009, Latacz-Lohmann and Hodge 2003, Lawton *et al.* 2010, Whitby 2000). The growth of landscape scale conservation thinking (Adams 2015, Lefebvre *et al.* 2014) is a part of this evolution which has been incorporated into Countryside Stewardship (CS) (2015-present), the AES which replaced the Environmental Stewardship Scheme in England (2005-2014). The Mid Tier of CS includes an incentive for groups of 4 or more farmers to participate in cross-holding environmental management by submitting a single, joint application. This innovation was introduced, in part, to address criticisms such as that in the White Paper for the Environment "*The Natural Choice: Securing the value of nature*" (HM Government 2011), which described the Environmental Stewardship Scheme as adopting a "piecemeal" approach which took "place on too small a scale to achieve overall success" and which, as a consequence, overlooked "crucial links, such as between wildlife sites and the wider countryside" (p 3) (HM Government 2011). It also reflects the increasing body of scientific evidence that demonstrates environmental management to be more effective when carried out at the landscape rather than the field or farm scale (Donald and Evans 2006, Dutton *et al.* 2008, Gabriel *et al.* 2010, McKenzie *et al.* 2013, Webb *et al.* 2010, Whittingham 2007).

It is widely acknowledged that the success of CS, as with all voluntary AES, requires land managers to be positively engaged with the scheme (Radley 2013, Wilson and Hart 2001). Indeed, the influential UK government commissioned, but independent, Lawton Report (2010)

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described farmers as "the bedrock of an effective [ecological] network" (p 58), and the White Paper for the Environment acknowledges the "vital role" they play in "achieving society's ambitions for water, wildlife, healthy soil, food production and the management of landscapes"(p 23) (HM Government 2011). It is because of this important role that farmer participation in AES has been widely studied (Brotherton 1989, Lastra-Bravo *et al.* 2015, Mills *et al.* 2013b, Prager and Freese 2009, Reed 2008, Siebert *et al.* 2006, Wilson 1996, Wilson and Hart 2001). Nevertheless, relatively little is known about UK farmers' attitudes and motivations towards cross-holding environmental management schemes. This compares unfavourably with our understanding of farmer participation in collective action in environmental schemes elsewhere, for example in Australia (Wilson 2004); Germany (Prager and Nagel 2008, Prager and Vanclay 2010); The Netherland (Franks 2010, Franks and Mc Gloin 2007, Renting and van der Ploeg 2001); America (Finley *et al.* 2006, Stevens *et al.* 1999) and in other selected OECD countries (OECD 2013).

The principal aim of this research is to address this deficiency, to explore farmers' perspectives on working collectively in formal AES. It reviews studies of UK farmers' views towards actual and hypothetical cross-holding, environmental management schemes found in the UK, and adds to this evidence by reporting findings from an on-line consultation in which UK farmers present their views on how the design of cross-holding AES might influence their participation decision. It then examines which of these findings have been incorporated into the design of CS, to suggest changes that may raise participation rates and therefore its effectiveness. The following section reviews the literature on UK cross-holding, landscape scale stewardship to identify farmers' perspectives of the barriers and the benefits of cross-holding environmental management schemes. Section 3 presents details of the on-line consultation exercise, and Section 4 reports the findings from the consultation. Section 5 discusses the implications of these findings for the design of cross-holding AES. Section 6 examines the extent to which the design of CS's Mid Tier incorporates farmers' views and concerns. Section 7 concludes by linking the effectiveness of landscape scale AES to an increase in the incentives offered to farmers to submit group applications.

## 2. Review Of Uk Farmers' Attitudes Towards Cross-holding Environmental Management

There have been many studies of the attitudes and views of non-UK farmers and land managers towards cross-holding environmental management initiatives (Prager and Freese 2009, Prager and Nagel 2008, Prager and Vanclay 2010, Primdahl *et al.* 2003, Primdahl *et al.* 2010, Renting and van der Ploeg 2001, Slangen and Polman 2002, Wilson 2004, Wiskerke *et al.* 2003). Two recent studies have reviewed this literature (Prager 2015, Prager *et al.* 2012). However, in a review of about 160 peer-reviewed publications on farmer participation in AESs, Siebert *et al.* (2006) concluded that the design of AES must be sensitive to local ecological, economic and social conditions, and to cultural preferences. These findings suggest that the attitudes and views of non-UK farmers may not form an especially reliable basis upon which to design innovative cross-farm AES for the UK. For this reason the literature review in this Section is restricted to collective environment-focused schemes and research applied to the UK.

The studies summarised in Table 1, which offer farmers the opportunity to join actual or hypothetical cross-holding schemes, found that most farmers would consider collaborating with neighbours in cross-holding AES (Dutton *et al.* 2008, Emery and Franks 2012, Franks and Emery 2013, MacFarlane 1998). However, when cross-holding environmental option HR8 was offered in Environmental Stewardship Scheme, its uptake was low (Franks and Emery 2013). The studies in Table 1 identify the barriers that prevent farmers turning interest into participation as:

- the preference of many farmers to work independently (Davies *et al.* 2004, Emery and Franks 2012);
- a lack of a pre-existing network or organisation which bring farmers together (Davies *et al.* 2004, Franks and Emery 2013);
- concerns about trust between members, typified by worries over the diversity of stakeholders interests (Franks and Emery 2013) and the enforceability of contracts (Emery and Franks 2012, Mills *et al.* 2011);
- the need for adequate financial compensation (Davies *et al.* 2004, Emery and Franks 2012, Franks and Emery 2013, MacFarlane 1998), even when farmers appreciated the environmental benefits of their collective action (MacFarlane 1998);
- a need for support from external advisors to arrange farmer meetings, lead group development and coordinate the submission of paperwork (Davies *et al.* 2004, Dutton *et al.* 2008, Emery and Franks 2012, Franks and Emery 2013, Mills *et al.* 2011, Southern *et al.* 2011);
- uncertainty about farmers' knowledge of environmental benefits arising from AES in general, and of landscape scale collective action in particular (Davies *et al.* 2004, Mills *et al.* 2011), and
- barriers imposed by the terms and conditions attached to cross-holding environmental management options, such as its competitiveness, and how individual farmer's AES payments are made (Davies *et al.* 2004, Franks and Emery 2013, Mills *et al.* 2011).

Research shows that many of these barriers also apply to farmers decision to participate in conventional, farm-by-farm AES (Siebert *et al.* 2006), but perhaps three have special relevance to joint-applications: the preference of many farmers to work independently, which is further exacerbated in areas without pre-existing support networks; specific financial issues raised by collective contracts; and the design of cross-holding schemes, including the validity of farmer-farmer contracts.

### Preference for independent working and third party support

The preference for independent working is a cultural as well as an economic issue. It is not surprising that cultural attitudes can provide a significant stumbling-block to the introduction of innovative practices (Emery 2015, Siebert *et al.* 2006). However, several studies

**Table 1:** Summary of published literature of cross-holding collective action in the UK

| Name of author(s) and date published | Location | Typical environment and farm type | Number of farms involved | Neighbouring farmers | Governance of landscape scale benefits | Details of inter-farm scheme | Principal research findings |
|---|---|---|---|---|---|---|---|
| MacFarlane (1998) | Lake District, England | Upland Cattle and sheep | 35 of 46 in target area sympathetic to the proposed scheme | Contiguous, within a ring block (ESA area) | Collaborative, with third party support in start-up phase | [Hypothetical scheme] Farmers invited to join a hypothetical third tire of Environmental Sensitive Area (ESA) payment to agree to manage features which crossed farm boundaries'' (p 583-585). | Support for cooperation underpinned by additional financial gain not by potential conservation benefit realised by cooperative action. Farmers with good relationships with neighbours more likely to respond positively |
| Dolman *et al.* (2001) | Oxfordshire, England | Lowland, river plain, arable | Initially supported by 15 out of 31 farmers approached, but all 17 subsequently interviewed supported scheme | Contiguous area of 110 square km | Collaborative, third part support in start-up phase | [Hypothetical scheme] Farmers invited to support a hypothetical, intra-farm, wider landscape management | Support for the scheme increased as farmers understood the likely ecological benefits. Visualisation of proposed scheme increased farmer support. |
| Davies et al. (2004) | Scotland | Covers a cross-section of Scottish farming types, including crofting | 17 existing environmental collective action groups (detailed analysis of 5 farmer-led collective actions | Close neighbours of one another | Farmer-farmer collaborative actions | [Funded Schemes] Included examples of bottom-up, farmer led collaboration and coordinated, third party supported collective action. | Farmers predominantly focused on business profitability; farmer's preference to work independently rather than in groups; farmers unlikely to be able to identify environmental benefits of cooperative action; difficult representing their own interests in the development of AES; development of existing informal networks rather than creating new ones. |
| Parrott and Burningham (2008) | Blackwater Estuary, Essex | Low-lying arable and grassland | 14 stakeholder interviews. No support for the option by farmers interviewed. | All farmed land in the Blackwater area suitable for intertidal habitat creation option | Collaborative, third party support only in start-up phase | [Hypothetical scheme] Farmer were interviewed to obtain their views of ESS's HLS "intertidal habitat creation" option. | Little support for the option due to: irreversibility of land use change;concern over the size and duration of compensation payments;upfront costs not repaid until farmer accepted into the scheme;<br>scheme too complex; farmers did not understand the need to create saltmarsh for conservation purposes;lack of confidence in design of scheme option as no direct evidence of benefits available. |
| Dutton *et al.* (2008) | Chichester Coastal Plains, West Sussex | Arable farming, producing vegetable and salad crops. | Targeted 42 farmers, all with contiguous land-holdings in the project area | All within the 10,000 ha target area | Cooperative, (farm specific conservation plans), organised by third party | [Funded scheme] Countryside Stewardship Scheme financed bespoke farm conservation plans provided by third party in consultation with farmers. | Farm-specific advice and bespoke conservation plans resulted in reduced farmer transaction costs;<br>all farmers carried out some conservation work; 11 implementing relevant conservation work, and 31 joining the proposed scheme. Scheme allowed habitat corridors to be built between farms.<br>Involved higher initial costs setting up the scheme |

**Table 1.** (*continued*)

| Name of author(s) and date published | Location | Typical environment and farm type | Number of farms involved | Neighbouring farmers | Governance of landscape scale benefits | Details of inter-farm scheme | Principal research findings |
|---|---|---|---|---|---|---|---|
| Southern *et al.* (2011) | River Glaven catchment, north Norfolk | Arable farming on mostly Grade 3 land | 27 farmers and 12 non farming landowners among 71 contacted stakeholders | All farmers live and work in the project area | Collaborative with third party support in start-up phase | [Hypothetical scheme] Adaptive framework to allow farmers to developed landscape scale scenarios. | Principal problems relate to lack of trust and clarity over environmental policy in general, short-term nature of environmental policy, and practical implementation of landscape scale conservation, including governance arrangements.<br>Initiation of landscape scale scheme would need help from external agent (e.g. a Project Officer), with partnership built on existing functioning partnerships, e.g. River Glaven Conservation Group |
| Mills *et al.* (2011)[1] | Case studies of exiting collective actions in Wales | Wide range of farming types involved | 13 case studies | All actively involved in existing collective actions | Collaboration, (direct governance), third party only involved in start-up phase | [Existing collective actions] Landscape scale, voluntary participation, groups. Built from existing network of farmers with shared traditional values and similar farming systems | Able to develop scheme adapted to local features and farming systems, members with common aims, strong local leadership, limited group size allows all to contribute to problem solving; payments distributed among the group by agreed contract. Third party only used to facilitate start-up and supply training needs as required. |
| Emery and Franks (2012) | Three case study areas in England | Arable, mixed farming, livestock farming | 33 farmers in total, (12, 10 and 11 in each case study area) | All farmed in one of the three case study areas | Farmers preferred coordinated, third party supported schemes & options | [Hypothetical scheme] Farmers were not given any guidance on the possible design of a landscape scale scheme | Overwhelming support for the principle of landscape scale schemes. Principal barriers included;<br>farmers preference to work independently showed strong cultural barriers to working together;<br>majority supported third party overview;<br>Perceived unwillingness of neighbouring farmers to participate; contractual issues; need for demonstrable benefits; and scheme flexibility, with respect to range of options available to select from. |
| Franks and Emery (2013) | Across England, but mostly upland areas | Livestock farming | 18 farmers, all participants in option HR8 in the EES's HLS | Spread across England | Collaborative, third party often involved, but only in start-up phase | [Funded scheme].Neighbouring farmers with boundary spanning environmental features can include Option HR8 in their AES agreement. | Flexibility of HR8 option is important. Generally attractive payments. Many agreements are agreed between farmer members of existing groups. Principal problems included;<br>Need for a third party to initiate initial discussions;<br>competitive nature of HLS;<br>need to finance up-front costs;agreeing primary use of land;<br>contractual arrangements. |

[1]This paper draws upon the findings of two research projects undertaken between 2004 and 2008 (Mills *et al*. (2006) and Mills *et al.* (2008)).

demonstrated the positive impacts that external advisors can make to address this barrier. Davies *et al.* (2004) suggested that ‘‘collective action coordinators’’ could help farmers identify local opportunities and respond to local circumstances; strengthen existing farmer-farmer networks; develop additional funding streams; and encourage farmers to become involved in local initiatives and programmes. Dutton *et al.* (2008) suggest external advisors would ideally work on a one-to-one basis with individual or groups of farmers. By bringing farmers together to discuss their options, collective action coordinators would help build viable farmer-groups, and in so doing increase the number of farmer-group applications. Franks and Emery (2013) found the majority of Higher Level Stewardship agreements that included the cross-holding option HR8 had been facilitated by a third party, including Natural England Project Officers, LEAF (Linking Environment and Farming), a National Parks Project Officer and specialist land management and grazing conservation trusts. Franks and Emery's (2013) study of HR8 agreements on moorland found higher support for third party assistance from farmers of moorland which has a wide diversity of stakeholder interests leading to conflicting views on the primary use of the farmland, and where local Moorland Management Associations were non-existent or lacked vitality.

### Scheme financial arrangements

Research showed that joint applications required up-front finance to pay for group meeting and to prepare contracts (Franks and Emery 2013). This suggests the current practice under Higher Level Stewardship of providing financial support for external assistance to individual farmers to develop their Higher Level Stewardship applications - which is not redeemable if the application is rejected - should be extended to farmer-group applications.

Several authors believe voluntary collective action schemes would not be possible without additional financial incentives. Southern *et al.* (2011), noting the lack of any strategic governance framework for delivering an integrated approach to landscape scale environmental management, suggested the State may need to lease or purchase areas of land which have high environmental value. Parrot and Burningham (2008) suggested introducing a ‘‘joint application payment’’, much along the lines of the amalgamation bonus payment suggested by Parkhurst *et al.* (2002) and Goldman *et al.* (2007). But such payments are not permitted under current AES rules (Rodgers 2004).

### Scheme design

Barriers to participation can also be related to the terms and conditions of AES and their individual environment management options. The only formal UK agri-environment related experience of joint submissions available to provide guidance on the design of Mid Tier was the Environmental Stewardship Scheme's Higher Level Stewardship option HR8 (2005-2015). This option had two significant scheme-design related barriers. Awards were discretional, creating a competitive environment for Higher Level Stewardship applications, which undermined trust between neighbouring farmers. And HR8 could only be included in applications under limited circumstances; where agreements covered ‘‘areas under more than one ownership that are to be managed for resource protection, inter-tidal flood management and/or wetland management, it may also be used to facilitate applications in landscapes with extensive archaeological or historic features’’ (Defra 2010). Although the literature shows farmers have concerns over their ability to hold cooperating farmers to account under joint agreement contracts, contract issues have not proved to be a particular problem with Higher Level Stewardship agreements which included HR8 (Franks and Emery 2013, Short and Waldon 2013). Although these applications involved farmers submitting a single joint application Natural England, who administer the scheme on behalf of Defra, each farmer was required to sign-up to an Internal Agreement as part of the joint application which details and clarifies their individual commitments and obligations (Defra 2011).

### Limitations

The literature on UK farmers' attitudes towards cross-holding environmental management may not be extensive, but it covers hypothetical and formally financed schemes in diverse landscapes (inter-tidal land, upland moorland, and lowland flood plains). However, relatively few farmers were involved in each study, and all but one focused on small geographical areas. Section 4 presents additional evidence, again taken from the farmers' perspective, of design features which would positively and negatively influence their decision to participate in a cross-holding AES. The on-line consultation, from which this evidence is taken, is described in the next section.

## 3. On-line Consultation And Descriptive Statistics Of Respondents

The on-line consultation was designed to reveal UK farmers' views towards cross-holding environmental management schemes and options. The consultation set out to target environmentally informed farmers because these respondents are best able to provide the detailed and knowledgeable responses required; (i) to inform decisions on whether changes, in this case to AES, are needed, and to advise on how to make those changes; (ii) to alert policy makers to concerns and issues which they may not have picked up through existing evidence or research; and (iii) potentially, to improve timeliness, so insights can be captured at an earlier stage in policy development: recent research has shown how early insights benefit and improve policy making (Phillipson *et al.* 2012). To achieve this aim, the consultation was publicised on the webpages of three national environmental NGOs; Linking Environment and Farming (LEAF); Game and Wildlife Conservation Trust (GWCT); and Farming Wildlife Advisory Group (FWAG). To access the wider farming population, the consultation was also advertised by the Royal Institute of Dairy Farmers and the Institute of Farm Management. The consultation document was posted on-line on the 23rd July 2011 and withdrawn on the 28th October 2011.

The consultation consisted of 28 questions. Ten solicited characteristics of the farmer, the farmer's family and farm, fourteen were related to aspects of cross-holding scheme design, and four Likert-type questions assessed

 

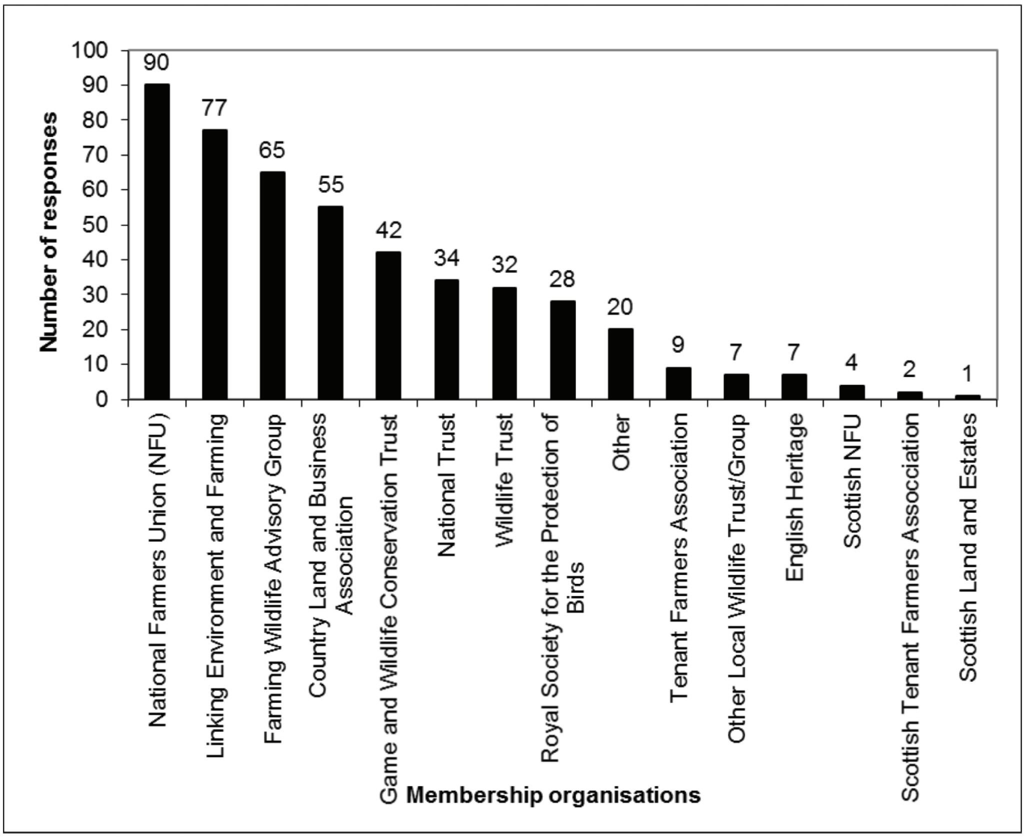


**Figure 1:** Membership of environmental and other organisations by 122 respondents to on-line consultation (multiple membership is possible)

the degree of independence farmers had over their participation decision. Some questions were preceded by clearly stated background information. The consultation did not specify how such a cross-holding scheme might be designed, because at the time of the consultation there was no indication cross-holding options would be included in future AES, clearly, therefore, details of the Mid Tier joint application opportunity were not available. This approach requires respondents to formulate their own ''model'' of how a joint scheme might be designed, and to present their views and opinions of the practical issues their ''model'' might give rise to. This provided respondents the freedom to reflect on a wider range of possibilities as they were not constrained by pre-formulated rules, thus providing a richer source of ideas and suggestions about the ways in which practical issues related to the design of a joint application scheme might affect their participation decision.

A total of 122 responses were received, 106 from farmers in England (from 36 counties), 11 in Scotland (from 5 counties), 5 in Wales (from 3 counties) and one from Northern Ireland.[4] The majority of the farms were larger than 200 ha (58%), the fewest less than 100 ha (19%). ''Mixed farming'' was the most commonly represented farm type (45%), followed by arable (35%) and livestock (16%), 8% were totally or partly horticultural farms, and 4% dairy farms. The consultation therefore adds to the available evidence by, for the first time, reporting the views of a large number of non-neighbouring farmers, over a wide geographical distribution. This means the responses are more likely to represent a wider range of farming, environmental and business circumstances than those reported in the case-study based literature reviewed in Section 2.

Of the 122 responses received, 77 were members of LEAF, 65 members of Farming and Wildlife Advisory Group (FWAG), and 44 members of Game and Wildlife Conservation Trust (GWCT): 31 (25%) were members of all three organisations (Figure 1). Respondents were currently involved in a total of 223 AES and conservation activities (Figure 2). The underlying proportion of UK farmers who are members of these organisations is considerably lower than these percentages, and it is likely the average UK farmer is involved in fewer environmental schemes.[5] Fourteen respondents were not currently in any formal AES, though three of these had previously participated in Entry Level Stewardship. This shows that the strategy of deliberately targeting farmers who have knowledge of environmental policy and experience of the practical application of environmental schemes and options was successful. However, compared to the underlying population of UK farmers, it can be speculated that respondents' are:

- more likely to have better access to advisory networks than non-members of national conservation NGOs;
- and as such, to have a better understanding of the potential positive environmental spill-over benefits from joined-up, cross-holding environmental management;
- and, arguably, as a result, be more prepared to accept higher levels and new types of risks that may be involved in collective action;
- and, in general, be better disposed towards innovative AES and options, and thus place different weight on

[4] One respondent farmed land in England and Scotland.

[5] At the time of the consultation, GWCT has a membership of about 22,000, FWAG of 8,000, and LEAF 2,500. The average number of environmental agreements the average UK farmer is involved in is not known.

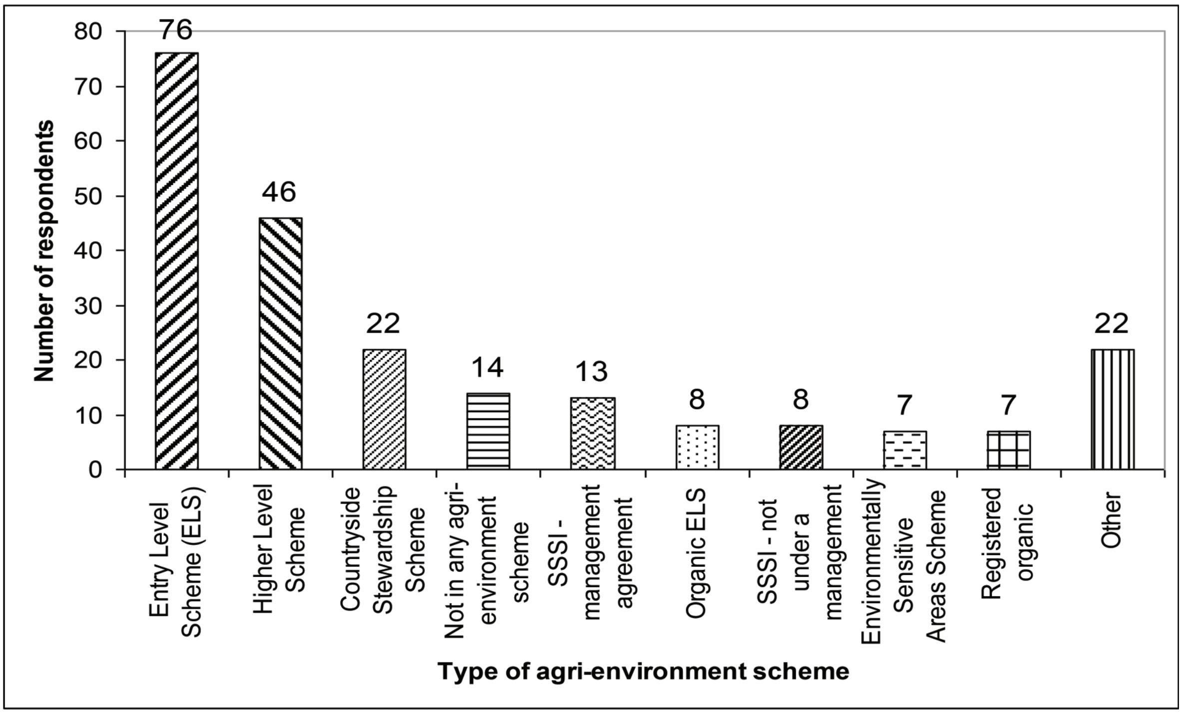


**Figure 2:** Agri-environment scheme(s) in which respondents (n=122) currently participate

the trade-off between commercial farming and conservation activities.

It is likely therefore that respondents are more favourably disposed towards cross-holding AES than the underlying population of farmers. Nevertheless, the targeting is justified when the intention is to garner views on practical designs, possible unintended consequences and details of the implementation of innovative policy initiatives (Cabinet Office 2012). This approach also lends itself to on-line data collection because there is no need for the responders to a consultation to be drawn from random or stratified random samples. But as a consequence, the research is best described as a consultation rather than a survey. Surveys typically gather views from random or stratified random samples drawn from the population to allow findings to be raised to the population level to provide, for example, estimates of support for a proposal or initiative. Findings from consultations cannot be used in this way. Because of this disadvantage, the views expressed cannot be expected to represent the full range of views of the underlying population of UK farmers towards cross-holding environmental management schemes. As a consequence, the study should be treated as a scoping study, the findings of which need further testing to establish how representative they are of the UK farming population.

## 4. Findings From The On-line Consultation Exercise

Before answering the question, "would you cooperate with one or more of your neighbouring farmers in a joint AES? (Assume you are compensated for loss profits and other costs incurred)" respondents were asked to read the following statement,

**Table 2:** Initial response to whether respondent would participate in principle in a cross-holdingagri-environment scheme*

| Intention to cooperate with one or more neighbour | Responses (%) |
|---|---|
| I think I would cooperate | 91 (74%) |
| Unsure – maybe | 19 (16%) |
| I don't think I would cooperate | 12 (10%) |
| **Total responses** | **122** |

*In considering their response, respondents were asked to assume the financial payment would cover their "costs and lost profits".

*This was a closed question, the responses indicate the options presented to respondents.*

"A principal reason for this survey is to ask for your views towards cooperating with neighbours to manage environmental features at a landscape scale. The area covered by the "landscape scale" and the type of coordination required remain unclear, but it might be expected to vary with the existing environmental characteristics of the landscape - so this [i.e. the first question] can only be a general question related to the principle of cross-holding environmental management."

Ninety-one (75%) responded that they would, in principle, participate in a joint AES, 12 (10%) would not, and 19 (16%) were "uncertain" (Table 2). Despite the wealth of experience and practical knowledge of environmental conservation among the respondents, the majority (62%) had never previously considered the issues raised by cross-holding agri-environment management schemes.

Table 3 shows respondents' justification for their answer. Forty-three (35%) of responses to the open question

 

**Table 3:** Reasons given by respondents to explain their initial response reported in Table 1 (n=121)

| | **Responses (%)** |
|---|---|
| Appears to be a sensible idea | 43 (33) |
| Generally unsure (*many in this category stated that "specific scheme details" - i.e. what is required of my farm - was an important consideration*) | 18 (14) |
| Some problem with their neighbour(s) mean cooperation unlikely | 29 (22) |
| Expressed concerns other than those related to the attitudes of neighbour(s)† | 17 (12) |
| Currently considered I do this already | 13 (12) |
| Instant reaction not possible (I have thought about this for a long time already) | 7 (5) |
| No response | 1 (1) |
| **Total reasons given** | 128* |

*Seven respondents gave two reasons.
†Most of the respondents expressing concerns, but not all, would not participate in cross-holding schemes.
*This was an open question, with no limit to the length of the response; responses were coded by the senior author.*

**Table 4:** Examples of current cross-holding activities

- I am already involved through the Cheshire Wildlife Trust's Gowy Connect project [in Cheshire, England].
- I already cooperate with 2 other neighbours with Higher Level Stewardship public access.
- I am happy to cooperate and we are already doing so in this part of the Cotswolds as we are part of the Higher Level Stewardship farmland bird initiative.
- In the Ant catchment valley (North Walsham, Norfolk, England) we've been doing it for 4 years. Natural England Multiple Objectives project (NEMO) was the reason for going into Higher Level Stewardship.
- We have already agreed to create some permanent pasture for a neighbour to graze and support our Higher Level Stewardship options with his cattle.
- Scheme already in place for co-operation on common land.
- I already cooperate with our local District Council and The Forestry Commission (as neighbours) in the recreation of lowland heath.
- Informally I already do - we are about to make scrapes for wading birds to complement existing scrapes on a neighbour's farm.
- We already do, so happy to continue.
- I have been cooperating for 12 years.
- I already do co-operate with 3 neighbours.
- Novel idea but not daft! Especially as my nearest neighbour is my landlord. Am already doing schemes to mirror his but to collaborate to far might alter the landlord /tenant relationship.
- I am already involved [in] .... a Nature Improvement Area* application with 30+ other farmers.

**Nature Improvement Areas were introduced in England in 2012 as a key Natural White Paper commitment. Their primary aim is to develop ecological networks within defined areas. The NIA refereed to here is the only one that was primarily led by farmers.*
*These responses were to an open question welcoming respondents to comment on the "idea of working jointly with your neighbour to manage your farm's natural resources at the landscape level".*

"what was your first reaction to the previous question?" were coded as 'collaboration is a sensible approach to environmental management', eighteen (14%) were coded as 'generally unsure', many of these referred to the importance of scheme detail to their decision, without detailing what particular aspects of the scheme would be critical to their participation decision. However, twenty-nine (22%) perceived collaboration would run into problems because of the unhelpful attitude of their neighbours. Sixteen respondents cited problems other than those coded above, the commonest of which related to additional bureaucracy (3).

Thirteen respondents (11%) were currently involved in some form of cross-holding agri-environment activity, details of which are presented in Table 4. These cross-holding actions range from 'cooperation for public access' (joining footpaths across different farmers' land for example) to participation in Higher Level Stewardship of Environmental Stewardship Scheme agreements. Presumably these farmers consider this to have a cross-holding element because all Higher Level Stewardship agreements are (i) concentrated in specified target areas, (ii) offer a restricted range of environmental management options, and (iii) prioritise the same environmental targets. Taken together, this means participants must include an almost identical combination of environmental management options, effectively delivering a degree of landscape scale management, despite there being no formal linkages between farmers or with third parties. However, 46 respondents were involved in HLS, so the majority had not interpreted their farm's contribution in this way.

One respondent was involved in either the Higher Level Stewardship's HR8 option or the Upland Entry Level Stewardship's UX1 option, the response did not make clear which. Other farmers were working with the Forestry Commission, the Cheshire Wildlife Trust, or in the Ant Valley water catchment area, Norfolk, England. One respondent was involved in an application for Nature Improvement Area status which was initiated by a group of farmers.

## Perceived problems and benefits of cross-holding conservation

All respondents were asked if they envisaged any particular problem working with their neighbours in jointly managed AES. Responses to this open question were coded and are presented in Table 5. Fourteen respondents (13%) believed that any problems that did

**Table 5:** Responses to question asking participants to identify 'particular problems they would envisage in working together with their neighbour to jointly manage their farm's natural environment' (n=110)

| **Particular problems arising from cross-holding environmental management.** | **Responses (%)** |
|---|---|
| *Problems related to neighbouring farmers* | |
| Neighbouring farms all managed differently or have different systems | 19 (18%) |
| Other farmers wouldn't be keen on the idea | 15 (14%) |
| Requires all farmers involved to be like-minded | 5 (5%) |
| Getting everyone to agree in the first place | 4 (4%) |
| *Problems related to the details of any cross-holding agri-environment scheme.* | |
| Legal issues (incl. monitor contributions) | 18 (17%) |
| Economic issues (reduce farm productivity) | 12 (11%) |
| Need to wait and see details of any proposals | 8 (7%) |
| Scheme administration and bureaucracy or paperwork | 4 (4%) |
| Would need to involve landlords on tenanted farms | 3 (3%) |
| *Respondents who could foresee no problems.* | |
| No problems whatsoever | 14 (13%) |
| All other responses (including: timing and coordination issues, strong dislike of neighbour, and have sufficiently large farm that can management land on a landscape scale without the need to involve neighbours) | 5 (5%) |
| **Total number of problems raised.** | **107** |

Respondents could identify more than one problem. Twelve respondents did not answer this question.
*This was an open question. There was no limit to the length of the response; responses were coded by the senior author.*

emerge could be addressed satisfactorily. Only two of these respondents provided details of their point of view. Both reported that their neighbouring farms were managed similarly to their own, and that they already cooperated with them. This confirms the importance of designing schemes that are easy to integrate into existing farming systems (Lobley and Potter 1998, Raymond *et al.* 2016, Siebert *et al.* 2006, Wilson and Hart 2001). The problems raised by the remaining respondents are discussed under two thematic headings: concerns with the views of their neighbouring farmers and the detailed small print (i.e. regulations) attached to any cross-holding AES.

## Problems caused by the views of neighbouring farmers

Forty percent of responses anticipated four discrete but different problems involved in working jointly with their neighbour(s); the diversity of farm systems (17%), their belief that neighbours would not support cross-holding schemes (14%), the requirement that farmers needed to be like-minded (5%), and the difficulty of getting sufficient agreement even with like-minded farmers (4%). Problems with neighbours are summarised in the following comments;

> "I wouldn't have my neighbour on my farm at any price".
> "The not interested neighbour still wants every acre to grow crops and has removed all his hedges."
> "Most of my neighbours do not like collaboration or being told what to do with their land."

When beliefs like these are based on knowledge of neighbours' opinions they form a significant barrier to the development of cross-holding environmental management applications. However, these views assume knowledge of responses to an innovative environmental scheme, which, as the consultation indicates, is an innovation the majority of even generally environmentally-aware farmers have never considered themselves.

## Detail of the proposed cross-holding agri-environment scheme

Forty-one percent of respondents thought the principal problem with working together to jointly manage farms' natural environment would depend on the details of any proposed scheme. Eighteen respondents (16%) were particularly concerned about the legal issues, including monitoring individual farmers' contribution to jointly submitted applications. Some of these respondents were concerned they might be penalised for the inactions of others, or that collaborators would renege on their agreement. For example;

> "I can only see this working as a voluntary scheme. I can't think of many farmers willing to rely on neighbours under an incentivised scheme such as ELS [Entry Level Scheme] for fear of being penalised for their neighbours' non-compliance."
> "[Cooperating farmers] could pull out on a whim, thus increasing the risks for those remaining".

As mentioned above, Higher Level Stewardship agreements which included option HR8 required farmers to sign an Internal Agreement, which clearly designates each farmer's responsibilities and obligations.

The issue of an appropriate level of payment was also raised by 12 respondents (11%) even though the question clearly stated payments would cover all costs associated with joining a joint scheme. Any financial compensation offered must comply with the World Trade Organisation's "green box" rules (Rodgers 2004). Therefore, compensatory payments are restricted to income foregone plus transaction costs plus any direct costs incurred. Although current payments already allow reimbursement of transaction costs related to organising cross-holding agreements, such as legal and advisory fees, the recent Common Agricultural Policy (CAP) reforms increased their transaction cost-related element of the payments for applications from farmer-groups by 10% (from 20% to 30% of the value of the AES payment (European Union 2013Article 28, Clause 6, Page L347/512)). However, the reforms did not alter any other rules for calculating agri-environment payments. Consequently, remuneration is not able to take into account any increase in effectiveness of AES resulting from cross-holding, landscape scale environmental management (Wynne-Jones 2013), nor can payments include any form of amalgamation bonus (Parkhurst *et al*. 2002, Parrott and Burningham 2008).

## Main benefits from working together to manage the natural environment

Respondents were asked what they believed to be the main benefits from working together to jointly manage the farms' natural environment. Even though the majority had never before considered cross-holding AES prior to responding to this consultation, sixty-seven (63%) believed cross-holding schemes and options would offer additional wildlife and biodiversity benefits compared to field- and farm-scale agreements (Table 6). A typical response was;

> "Environmental outcomes would surely be far better. Greater opportunity for a properly designed environmental scheme rather than little bits and pieces of habitat creation which aren't necessarily co-ordinated to benefit any relevant species other than the greater-spotted bureaucratic box-ticker which previous schemes have been designed to suit."

**Table 6:** The principal benefits to respondents from working with their neighbours in the joint management of their farms' natural environment'' (n=106)

| Principle benefits of joint management. | Responses (%) |
|---|---|
| Benefits to wildlife and biodiversity | 67 (63) |
| No benefits | 13 (12) |
| Financial benefits | 11 (10) |
| Do not know what benefits there may be | 2 (2) |
| Other | 13 (12) |
| Total responses to this question. | 106 |

*This was an open question, with no limit to the length of the answer; responses were coded by the senior author.*

Eleven respondents (10%) believed there would be financial benefits from working together. One commented,

> "We were able to get significant grant aid for a large project that individually would not have been possible" [no additional details were given].

However, thirteen respondents (12%) believed working together would not deliver any environmental benefits, though some respondents took this view because they believed there were already sufficient environmental features in their area. Others, as reported, believed high participation rates in agri-environmental schemes already effectively deliver a cross-holding approach. One respondent believed cross-holding options would add no further benefit because;

> "I have already put in place most of the potential collective options listed [i.e. those collective options specifically discussed in the consultation]".

## Support for different types of cross-holding agri-environment options

Respondents were asked to select from a list of environmental management options which they would implement on their farm, given they would receive acceptable financial compensation for doing so. All of the options, presented in Table 7, would be more effective if they were implemented on a scale larger than the typical farm. Not all respondents gave answers for each option, possibly because some were not applicable to their circumstances. Table 7 classifies these options as either "collaborative" or "coordination" using Boulton *et al.*'s (2013) definitions; that is, "collaboration" are collective actions which require land managers to "meet, work together and maintain a dialogue … for a project to deliver the desired outcomes" (p 4), whereas "coordination" allows land managers to work towards the same objectives in isolation from one-another, typically coordinated by a third party. These definitions, which establish that direct working between individual participants is not necessary for the project to deliver its desired outcome (p 4), have also been used by Prager (2015) and Raymond *et al.* (2016). For example, sequential cutting of hay by neighbours is a collaborative option as it requires neighbouring farmers to interact to schedule

**Table 7:** Respondent's views towards cooperative and collaborative cross-holding environmental management options

| | Responses | | |
|---|---|---|---|
| **Coordinated (farmer-third party) collective action** | Yes | No | (%)* |
| Create continuous networks of hedges/ditches (joined up with your neighbour's hedges/ditches) | 107 | 10 | 91% |
| Extend environmental management into areas close to existing high nature value sites (such Site of Special Scientific Interests) | 73 | 15 | 83% |
| Create a network of water features e.g. ponds | 79 | 33 | 71% |
| Locate trees in designated sites that best suit the landscape (i.e. perhaps not always where you would prefer them) | 74 | 36 | 67% |
| Expand woodland you may have on your land | 58 | 36 | 62% |
| Allow land to revert to semi-natural habitat | 54 | 56 | 49% |
| **Collaborative (farmer-farmer) collective action** | | | |
| Co-ordinate the timing of hay cutting with neighbours | 63 | 24 | 72% |
| Create areas of wetland - allowing the water table to rise | 40 | 62 | 39% |

*% of yes to total responses received. Not all respondents answered each question.*

their activities. The option "create a continuous network of hedges/ditches" is a coordinated action as it does not need discussions with neighbours, though it may benefit from assistance of a third party with a knowledge of landscape scale environmental features. Respondents were more supportive of coordinated (farmer-third party) options (Table 6). "Coordinate the location of hedges/ ditches so they joined up with neighbours hedges/ ditches" was supported by 91% of respondents, a willingness to "extend environmental management into areas close to existing high nature value sites, such as Sites of Special Scientific Interest by 83%, and the creation of "a network of water features, e.g. ponds" on their land by 71%. The strongest support for a collaborative option was "co-ordinate the timing of hay cutting with neighbours", by 72% of farmers.

Rather unexpectedly, given the literature on participation in AES which suggests farmers prefer flexibility in selecting, managing and siting environmental management options (Siebert *et al.* 2006), seventy-four respondents (61%) said they would be prepared to "locate trees in designated sites that best suit the landscape, (i.e. perhaps not always where you [i.e. the respondent] would prefer them)". Among those options to receive the least support was "create areas of wetland – allowing water table to rise" (39%) and "allow land to revert to semi-natural habitat" (49%). Both options have longer term implications for land use, which research suggests farmers consider unfavourably, perhaps because, by taking land out of production, these options go against farmers view of themselves as food-producers (Emery and Franks 2012), perhaps because they reduce flexibility of future farm development plans because they result in longer-lasting change (Siebert *et al.* 2006), or perhaps because many are less easy to reverse (Hodge and Reader 2010). However, these disadvantages also apply to the option "increasing the area of woodland", which was supported by 67% of respondents.

The willingness of a majority of respondents to plant trees and create ponds, hedges and ditches where they would be most effective given the configuration of environmental elements across the landscape is an important finding because the placement of environmental management options, whether collaborative or coordinated by a third party, is essential to the development of an integrated and enhanced ecological network.

The options listed in Table 7 could be delivered through either a whole- farm or a part-farm AES. Part-farm schemes are particularly useful for integrating a large farm into the existing ecological network (Wilson and Hart 2001) and where farmland is highly productive (Franks and Emery 2013).

### Pest and invasive species control

A key benefit of connected landscapes is improved species mobility (Natural England 2015a). But this increase in landscape permeability may also benefit species which have undesirable impacts on the environment. For example, non-native invasive species, crop and livestock pests and diseases, and vermin, each of which may impose considerable costs on farm businesses. Before asking respondents to answer the yes/no question, "would you be willing to work with your neighbour in joint AES agreements if in doing so some of the target species/pest species you supported/enhanced included [in turn: foxes; badgers; rabbits; bat; deer; Turtle Doves]?", consultees were presented with the following statement,

> "In addition to helping many rare target species, it may be that landscape scale management also helps species that many farmers might consider to be pests".

Seventy-three percent would not support cross-holding environmental management if it benefited fox populations; 74% would be unsupportive if the changes benefited badger populations, 89% unsupportive if the changes benefited rabbit populations; 58% unsupportive if deer populations were supported. However, 79% and 88% would support collaboration if it helped Turtle Dove and bat populations respectively. Respondents were then asked the yes/no question "would an option for pest management within a cross-holding scheme satisfy any fears you may have over its impact on pest populations?" Seventy-four percent said it would, giving clear support to offering pest management options as an environmental management option within a cross-holding AES. Whilst pest control may be a controversial issue, it is clear that support for cross-holding schemes would fall if they had adverse, albeit unintended, consequences. Pest management options not only largely addressed this concern, but may deliver additional benefits, given that uncoordinated attempts to control the movement of undesirable species can be ineffective, and even counterproductive (Coulson *et al.* 2004).

## 5. Further Discussions On The Consultation Findings

The findings from the consultation add to the evidence presented in the literature review by reporting the views of a large number of environmentally-informed farmers whose geographical separation suggests they are more likely to be subjected to a wider range of diverse environmental and farming circumstances than respondents in the case study-based studies. They confirm many comments reported in the literature. But raise two particular issues, both of which may affect scheme effectiveness, which are discussed here: awareness of the expected environmental benefits of landscape scale schemes, and the need to offer collaborative and coordinated environmental management options in landscape scale AES, to help allow for uncooperative neighbours.

### Prior awareness of landscape scale environmental benefits: framing cross-holding benefits

The consultation findings suggest that a respondent's prior awareness of the potential improvement in environmental effectiveness delivered by cross-holding management options was an important determinant of their participation decision. This supports recent research which emphasises the importance of farmers' perceptions of scheme effectiveness to their participation decision (Mills *et al.* 2013a, Mills *et al.* 2013b). Despite the high proportion of respondents with experience of AES, the majority (62%) had never considered cross-holding environmental management prior to this consultation; it is unlikely a less environmentally aware and committed

**Table 8:** Types of landscape scale stewardship arrangements (adapted from Boulton et al. (2013) and Uetake (2014))

| Governance mechanisms for delivering effective landscape scale environmental management | Boulton et al.'s (2013) classification of Uetake's typography of collective action | Example from UK AES |
|---|---|---|
| **Effective landscape scale action without collective action** | | |
| Landscape scale achieved by scheme design which requires neighbouring farmers to select similar environmental management option, generating landscape scale impacts if participation achieves critical mass. | No formal or information contact between farmers – see text(Not classified by Boulton et al. (2013)) | • Environmental Stewardship Scheme Higher Level Stewardship agreementsHigh Tier of Countryside Stewardship |
| **Typography of collective action (Uetake 2014)** | | |
| Type 1: Organisational style collective action in which farmer are members of independent organisation | Farmer-farmercollaboration | • No such organisations in AES the UK* (for example, compare with agri-environment cooperatives, in the Netherlands) |
| Type 2: Farmer activities coordinated at the landscape scale by specialise third parties working with individual farmers | Farmer-third partycoordinated | • HR8 option in Environmental Stewardship Scheme Higher Level Stewardship agreements *when farmers hand over total managerial responsibilities to the third party* (e.g. specialists land management and grazing trusts).<br>• Capital Grants element of Countryside Stewardship |
| Type 3: Farmer-farmer meetings and dialogue. | Farmer-farmercollaboration | • HR8 option included in Environmental Stewardship Scheme Higher Level Stewardship agreements *which is manged by the farmers.* |
| Type 4: Farmer activities coordinated at the landscape scale by specialist "third parties" who work with groups of farmers. | A combination of farmer-farmer collaboration and third-party coordination(Not classified by Boulton et al (2013)). | • Mid Tier of Countryside Stewardship involving farmer-group applications, agreed between farmers and coordinated by facilitators see Defra 2015 for details see Defra 2015 for details). |

*There are examples of Type 1 organised collective environmental-focused action in the UK which is outside formal AES.

farming population would be any better informed. It appears, therefore, that important policy reviews, such as Lawton *et al.* (2010), and academic studies which report benefits from cross-holding action at the landscape scale (Dutton *et al*. 2008, Ewald *et al*. 2010, Gabriel *et al*. 2010, MacFarlane 1998, Merckx *et al*. 2009, Parrott and Burningham 2008, Southern *et al*. 2011) have not filtered through to farmers.

Social science research confirms that the way stakeholders frame issues and conflicts can help explain the success or failure of initiatives (Gray 2004). This suggests information campaigns which effectively present and explain the scientific evidence of the environmental benefits arising from cross-holding environmental management would increase the number of group applications. Farmers are bombarded by information and instructions, through membership groups, letter shots, demonstration farms and events, so these mechanisms could all be used for this purpose also. But more radical approaches might involve identifying local champions for landscape scale environmental management, or creating a professional farm management qualification as a requirement to receive compensation payments. Such a certification scheme could offer CPD training events which aim to develop a more professional attitude towards environmental management (Lobley *et al*. 2013).

## Choice of environmental management options

A key reason for introducing cross-holding schemes is the weight of evidence that AES effectiveness will increase if it is designed at the scale of the targeted species and habitats (Kleijn *et al*. 2011, Tuck *et al*. 2014). Although Kleijn and Sutherland (2003) recommended that ecological evaluation becomes an integral part of all schemes, provision for monitoring of AES effectiveness continues to be criticised (European Court of Auditors 2011). This is because measuring effectiveness is complicated by difficulties identifying the counter factual position (Hanley *et al*. 1999, Hodge 2000), a general lack of pre-stated, specific measurable objectives (Mountford *et al*. 2013), and the need for dedicated environmental impact monitoring (Finn *et al*. 2009). These problems mean monitoring tends to be expensive. Natural England has a £1.8m budget for this purpose, part of which is being used to establish environmental baseline data for 7% of CS whole-farm agreements (based upon Defra's "Monitoring and Evaluation Plan 2015-2020" (Chesterton, NE Evidence Programme Manager, *pers com*)).

If these and follow-on studies confirm CS does increase scheme efficiency, it would provide policy makers with the option to rebalance the area of land used to produce environmental and food goods. A more effective CS would allow more environmental goods to be delivered from the same area as the less effective farm- and field-scale AES, or the same amount of environmental goods from a smaller area of farmland, thereby releasing land for food production. As such, CS would provide a practical approach to delivering sustainable intensification, the policy that seeks to increase both agricultural production and ecosystem services from land (Elliott *et al.* 2013, Foresight 2010, Franks 2014). Carefully designed assessments may also help identify the landscapes within which cross-holding schemes would be most beneficial.

Table 8 classifies landscape scale management opportunities offered through AES in England based on Uetake's (2014) typology of collective action stewardship and Boulton *et al.*'s (2013) definitions of ''collaboration'' and ''coordination'' (see Section 4). It allows for the view expressed in the consultation that participation in Higher Level Stewardship Scheme can contribute to landscape scale environmental management, despite an absence of collaboration or coordination. This is because Higher Level Stewardship targets farmers farming in a small geographical area, requires them to select from the same, small number of environmental management options, all of which are designed to prioritise the conservation and preservation of the same environment habitats and species. However, in such cases, effectiveness is dependent on the participation of a critical mass of eligible farmers to overcome the ''threshold effect'' (Sutherland *et al.* 2012). This effect refers to the need for a minimum number of participants to trigger perceptible improvements to the state of the natural environment (Dupraz *et al.* 2009). The number of Higher Level Scheme participants which comprise this ''sufficient'' number will depend on the characteristics of each site, as it is likely to vary with; farm and field size and their spatial distributions; the proportion and spatial distribution of high nature value features on collaborators' and non-collaborators' land; the location and condition of existing environmental features; and the number and type of cross-holding options taken-up. It is likely that collaborative and cooperative AES would have a lower critical mass threshold because of the additional environmental benefits from collective action (Benton *et al.* 2002, Chamberlain *et al.* 2000, Tscharntke *et al.* 2005). Three examples of landscape scale management in Table 8 refer to the recently introduced CS; the Higher Tier, Mid Tier and Capital Grant finance. These are discussed in the following section.

## 6. Farmers' Priorities And Concerns And The Design Of Countryside Stewardship

The evidence presented in the literature review and consultation suggest that the majority of farmers will at least consider participating in a cross-holding scheme (Emery and Franks 2012, Franks and Emery 2013, MacFarlane 1998). Although this study has revealed substantial barriers to converting intentions into actions, research suggests that the level of participation in AEs increases if they are designed taking famers' views into account (Beedell and Rehman 1999, Reed 2008). Table 8 developed Uetake's (2014) and Boulton *et al.*'s (2013) classifications, and argues that CS's Higher Tier, Mid Tier and Capital Grant finance can all contribute towards enhancing environmental management at the landscape scale. This Section introducing these elements of CS, and explores the extent to which the concerns of farmers' revealed in the literature and the on-line survey have been incorporated into their design. It them proposes changes to CS which may increase the number of farmer-group applications in the next round of AES reforms.

### Higher Tier Countryside Stewardship

The *Countryside Stewardship Manual* (Natural England 2015b) confirms CS will remain entirely voluntary and be structured around three main elements: Higher Tier; Mid Tier; and Capital Grants. Successful applications to High and Mid Tier will be expected to dedicate a minimum of 5% and 3% of the farm area to relevant management options respectively. Higher Tier is essentially similar to Higher Level Stewardship; it is a whole-farm discretionally scheme, targeted at high nature value regions, which requires farmers to select from a small menu of environmental options. Therefore, if the number of participants exceeds the region's critical mass, it can, in the same way as Higher Level Stewardship, deliver cross-holding environmental impacts.

### Mid Tier of Countryside Stewardship

Like Entry Level Stewardship, Mid Tier is a whole-farm scheme which requires farmers to choose from a menu of environmental management options, with each option allocated points. However, it has three key differences. Mid Tier is discretionary, applications are ranked, and the highest ranked are funded, working down the list until the budget is exhausted. Therefore, to be funded an application must score above the ''threshold'' points/ha. Secondly, applications may be presented by groups of at least four farmers with ''adjoining (or mainly adjoining) holdings'' that cover more than 2,000 ha, unless it ''fits a smaller, obvious environmental boundary''.[6] Thirdly, it makes available financial support to facilitate third party advice from a Facilitation Fund of £1.2 million (Defra 2014). Group applications are further incentivised by being given priority in the Mid Tier scoring process (Defra 2014).

The Facilitation Fund meets one of the farmers' key requirements for participation in landscape scale AES, provision of financial support to pay for meetings, advice and completion of paperwork (Natural England 2016). Facilitators can help to overcome farmers' general preference to work independently and help to address the handicap faced by farmers farming in areas which lack existing support networks. The facilitator fee can be up to £12,000/annum over the life-time of the agreement. Mid Tier also addresses farmers' concerns about the legal status of farmer-farmer contracts by requiring each farmer in a farmer-group to sign an individual contract with Natural England. However, there is no provision for up-front financial payments to cover meeting and arrangement costs (Franks and Emery 2013), a facility available to farmers under Higher Level Stewardship.

The consultation revealed that 11% of farmers' were concerned about the value of financial compensation offered for joint applications. Current compensation payments are not allowed to reflect a farmer's individual, or collective contribution to the delivery of environmental goods (Rollett *et al.* 2008). However, Mid Tier does incentivise joint applications in their ranking for funding, and additional incentives could be offered if joint applications do improve AES effectiveness. A precedent for this has been set by the derogation offered to registered organic farmers on the area of land they need to enter into ''greening'' to receive their full

[6] This refers to the total area of the holdings, not to the size of the area under joint environmental management.

 

support payments. This derogation was granted on the basis that organic farming systems provide more environmental benefits than "conventional" farms; this is precisely the goal of farmer-group applications.[7] A resource- rather than payment-based incentive would be especially attractive to those farmers who are not willing to enter productive land into AES (Siebert *et al.* 2006).

Farmers in existing Environmental Stewardship Scheme agreements are not able to apply to CS Mid Tier until their existing contract expires. As the Environmental Stewardship Scheme agreement may have started at any time between 2005 and 2014, it is unlikely that the existing contracts of at least 4 neighbouring farmers, of suitably size, will expire at the same time. Therefore, the precedence set by the Upland Entry Stewardship – which allowed farmers to switch from their existing Entry Level Stewardship to the newly introduced Upland Entry Level Stewardship as soon as it opened - should be extended to farmer-groups as soon as their joint application to Mid Tier is accepted.

Another problem is that Mid Tier is a competitive scheme, which may restrict farmers willingness to share details and thus reduce the size and number of joint applications (Franks and Emery 2013). There is also an assumption that there are sufficient suitably qualified advisors to satisfy the demand for this service.

### Capital Grants of Countryside Stewardship

Capital Grants provide finance to improve hedgerows and boundaries, water quality, and for the development of "implementation plans, feasibility studies, woodland creation (establishment), woodland improvement and tree health" (Natural England 2015b: p 3). A maximum of £5,000/holding is available for improvements to "hedgerows and boundaries", and up to £10,000 for "water quality grants".[8]As these funds are available through the High or Mid Tier, or as stand-alone agreements, they can therefore be used in whole- and part-farm schemes. As a part-farm, standalone agreement it may attract farmers who would like to contribute to environmental management, but who cannot financially justify entering 3% or 5% of their farmland into the whole-farm Tier. However, only eleven of CS's 114 approved capital items can be selected in standalone applications. Nor can Capital Grants be used to extend a buffer zone around a Site of Special Scientific Interest, and water quality improvement grants are restricted to farms in Catchment Sensitive Farming priority catchments. Additionally, all woodland creation grants are reserved for Higher Tier agreements (Natural England 2015b: p 4-6). The lack of options available for part-farm, standalone agreements will reduce participation rates. Relaxing this constraint may allow Capital Grant finance to make a more valuable contribution to integrating existing environmental features into the ecological network.

### A further consideration: budgetary constraints

Can collective action lead to more effective AES without increasing budgetary expenditures? The agri-environment budget for England between 2015 and 2020 is in excess of £2 billion. Existing Environmental Stewardship Scheme contacts will continue to be paid, leaving a total CS budget for 2015-2020 of £925m. Of this, £380m is earmarked for the Higher Tier, £410m for Mid Tier and £85m for Capital Grants (Dixon 2015). Therefore, an increase in the budget for one element of CS reduces funding on another. One way to raise effectiveness within these budgetary constraints is to target each element of CS where they can be most effective (Sutherland *et al.* 2012). For example, Capital Grants could be targeted at landscapes where in-filling existing landscape habitats creates or significantly improves the existing, ecological network (see, for example, Donald and Evans 2006, McKenzie *et al*. 2013).

Alternatively, the budg*et al*lowances for each tier could be made more flexible. All CS awards are discretionary, so only the highest ranked applications are funded. This may mean an application to Higher Tier is rejected even though it benefits the ecological network more than the lowest ranked funded Capital Grant application, or vice-versa. Such flexibility in the budg*et al*located to each element of CS might therefore increase its effectiveness.

The financial compensation rules applied to AES do not apply to payments made by the beneficiaries of the environmental management, which is the principle underpinning Payments for Ecosystem Services (PES) (Reed *et al*. 2014).[9] Many existing PES schemes involve water related projects which typically require the cross-holding collective action (GEF 2010). Because PES compensation payments are not regulated by the EU Commission, PES schemes can offer farmers larger compensation payments. For example, they are able to off the "joint application payment" suggested by Parrot and Burningham (2008), or the "amalgamation bonus" considered by Parkhurst and Shogren (2007). These payments could also be scaled according to the number of participants or the total area enrolled in the collective action (Goldman *et al*. 2007), which Kuhfuss *et al*. (2016) show, under certain scheme designs, can have the additional benefit of increasing farmer participation.

## 7. Conclusions

An important finding from the literature review and the consultation was the interest shown by farmers in cross-holding environmental management, even when it has not previously been considered (Dutton *et al.* 2008, Emery and Franks 2012, Franks and Emery 2013, MacFarlane 1998). This should be encouraging to UK policy makers, as without this initial interest cross-holding schemes could not succeed. Moreover, the majority of respondents to the consultation were prepared to relinquish control over the selection and location of AES options if they believed this would deliver additional environmental benefits. If these responses are representative of the UK farming population, this should also encourage policy makers, because locating specific environmental management options in their optimum locations from a landscape rather than from a field or farm perspective is an essential requirement for creating and enhancing ecological networks.

The literature review suggests the principal barriers to cross-holding schemes are: the preference of many

[7] "Greening" requirements link farmer's entitlement to the full Basic Payment Scheme on their compliance with land use measures on at least 5% of their arable farmland (derogations apply to small sized farms).

[8] The scheme also provides non-competitive support for organic conversion and management, for which all eligible applications will be funded.

[9] PES refers to new business models where private businesses rather than government pays for the production of ecosystem services.

farmers to work independently (Davies *et al*. 2004, Emery 2015, Emery and Franks 2012), which is further exacerbated in areas without pre-existing support networks; specific financial issues raised by collective contracts, and the structural design of cross-holding schemes, including the validity of farmer-farmer contracts. There is also ample evidence that success of cross-holding schemes require provision of third party support to help farmers establish networks and to assist with scheme paperwork. In addition, the consultation showed support was linked to farmer's prior awareness of the additional environmental benefits of landscape scale schemes, and the need for schemes to offer a combination of "collaborative" and "coordinated" environmental management options. Although respondents to the consultation were concerned that successfully designed landscape scale schemes might support unwanted as well as target species, most believed this could be addressed by including suitable pest management control options within AES.

The analysis shows that each element of Countryside Stewardship has the potential to contribute to enhancing ecological networks. Higher Tier may achieve this if it is supported by a critical mass of farmer participants. Mid Tier offers incentives to farmer-groups to submit joint applications. It finances third-party assistance through its Facilitation Fund, as requested by many farmers (Davies *et al*. 2004, Dutton *et al*. 2008, Emery and Franks 2012, Franks and Emery 2013, Mills *et al*. 2011, Southern *et al*. 2011). It also requires farmer-groups to agree individual contracts with Natural England rather than with one another, thus addressing concerns over contractual issues (Emery and Franks 2012, Mills *et al*. 2011). However, it is discretionary, does not provide up-front finance, requires at least 4 farmers, farming over 2,000 ha for each joint application, and does not allow neighbouring farmers to end their Environmental Stewardship Scheme agreements early to synchronise submission of joint applications. In addition, it is a whole-farm tier. When used in stand-alone agreements, Capital Grants scheme can be used to integrate parts of farms of farmers who do not wish to participate in the Higher or Mid Tier, into the ecological network. Therefore, although CS represents a significant move towards managing the environment at a landscape scale, it has not addressed all farmers' concerns.

Incentivising farmers to change their traditional ways of working is key to attracting high participation (Davies *et al*. 2004, Emery and Franks 2012, Franks and Emery 2013, MacFarlane 1998, Siebert *et al*. 2006). Though compensation payments are constrained by the EU Commission's rules, which themselves are based on World Trade Organisation agreements, there is precedence to offer additional resource-based incentives, such as reducing the area of land farmers in farmer-groups have to place in "greening", if additional environmental benefits do result from group applications. If monitoring studies are able to confirm these environmental benefits, then cross-holding environmental management could become a mechanism for simultaneously delivering increases in environmental and food goods from land.

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# Multi-year agro-economic modelling for predicting changes in irrigation water management indicators in the Tadla sub-basin

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**ABSTRACT**

The irrational use of irrigation water resources is a major constraint to agricultural development in the watersheds of Morocco, including the Tadla sub-basin. It is essential for these areas to have effective instruments for managing and organizing the control and distribution of water resources and to ensure their protection and conservation. Within this context, this study focused on the Tadla sub-basin, where there has been a marked decrease in the supply of irrigation water. Using a dynamic agro-economic model called 'TADMOD' (for TADla Basin MODel), which classifies agricultural units according to their different sources of irrigation water, the study's main purpose was to analyse the interannual variations in selected irrigation water management indicators. One of the most important indicators studied here was irrigation water shadow price between 2011 and 2020. The results of the analysis revealed important differences in this indicator value among the observed agricultural units. Its average value, calculated by TADMOD, was about 1.33 MAD[4] (Moroccan Dirham) per cubic metre of water. The model showed that, over the ten simulated years, reduced water supplies in the Tadla sub-basin would lead to an increase of 33.2%, on average, in the irrigation water shadow price and to a decline in the cultivated area and total consumption of irrigation water. The reduction in the cultivated area would lead to a slight fall in value-added, estimated at 3,180.78 million MAD per year in 2010-11, the first year of simulation.

**KEYWORDS:** Agro-economic modelling; water resources management; water access; water shadow price; agricultural profit; Agricultural Territorial Unit; Tadla Sub-Basin

## 1. Introduction

Morocco's water resources are influenced mainly by a strong spatial and temporal heterogeneity in water volume and by their scarcity, 22 billion $m^3$/year (CESE, 2014), the equivalent of 660 $m^3$/pers.year. On the basis of the water scarcity indicator, defined by Falkenmark (1989) as the volume of renewable water per capita, Morocco is facing a chronic water shortage. The management of the country's water resources is currently experiencing major problems, hindering the development of these resources in an integrated and consistent manner (MEMEE, 2010). These problems relate to watershed protection, water quality, population growth, climate change, water resources valuation and the rational use of water resources. Morocco's commitment to rationalizing the use of its water resources is crucial to ensuring their quantitative and qualitative sustainability. One of the most critical activities in this regard is agriculture.

Agriculture is a strategic sector in the socio-economic development of Morocco (Benabdelouahab *et al.*, 2015). Since the 1960s, the country has implemented various agricultural and rural development programmes and structural reforms (e.g., dam construction, agricultural structural adjustment programs and the Green Morocco Plan strategy) aimed at ensuring food security and economic growth (Desrues, 2005). Currently, the agricultural sector is of paramount importance in the national economy in terms of its contribution to the Gross Domestic Product (GDP), its role in employment (it accounts for 80% of rural employment) and its contribution to foreign trade (Toumi, 2008).

Morocco has recognized the need to upgrade, restructure and redefine its agricultural activities and revise its

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[4] At the time of writing (mid-March 2016), MAD1.00 was approximately £0.07, $US0.10 and €0.09.

agricultural policy accordingly so that it is adapted to the global context of food security, climate change, rising prices of agricultural products and the fight against poverty. It has taken the first steps along this road with the development of the Green Morocco Plan, aimed at making agriculture the main growth engine of the national economy. Agriculture in Morocco depends on climatic conditions, however, and therefore water control is crucial to its socio-economic development. The climatic insecurity results in costly food insecurity in the country (massive food importation is needed in dry years) and greatly affects living conditions in rural areas, with repercussions on other economic activities. The main focus of the new agricultural policy has been on long-term and large-scale irrigation schemes, particularly in the Tadla plain. Irrigation efficiency is still poor, however, with the flood irrigation systems that dominate 90% of this area (according to the Regional Direction of Agriculture) having an efficiency rate of 50% or less. In addition, productivity per irrigated hectare is below its potential for some farms, economic efficiency is 69% on average and a cubic metre of water is not sufficiently valued in terms of high-value crops (Lionboui *et al.*, 2016). The incentives for effective water management are still limited in scope and the price of water does not reflect its scarcity. There is therefore a need to develop more efficient irrigation and agricultural production systems by promoting irrigation techniques and cropping systems based on a higher value of water. Water policy strategies need to be based on demand management, the development of participative management and a realistic socio-economic valuation of water. These strategies would enhance water resource mobilisation efforts by promoting its efficient use and would provide Morocco with the means to accommodate drought risk by having appropriate solutions for managing water shortages.

The non-rational allocation of irrigation water is a major obstacle to the development of vegetable production chains in the Tadla sub-basin. The adoption of efficient irrigation technologies would help to better manage this activity and improve production and profitability.

The agro-economic model TADMOD, for TADla basin MODel, (Lionboui *et al.*, 2014) was developed to identify irrigation efficiency issues in the Tadla sub-basin. In its static version, TADMOD does not predict interannual variations of water management indicators. This study focuses on the development of a dynamic agro-economic version of this model for the sub-basin of Tadla that enables interannual variations in water management and socioeconomic indicators to be predicted, taking into account the various development projects planned for this area. This tool has been achieved in order to help stakeholders to control water management and adopt the most appropriate agricultural policies.

## 2. Materials And Methods

### Modelling water resources management at the sub-basin level

Water management has become a central topic in economic literature in recent decades. In many semi-arid regions of the world, addressing issues related to the scarcity of water resources is crucial to development (Cirilo, 2008). The high value of water in these areas can be a quantitative and qualitative constraint to its domestic, industrial and, in particular, agricultural use. At the international level, the focus initially was on a single source of water, either surface water or groundwater (e.g., Gisser and Sánchez (1980) and Feinerman and Knapp (1983), who discussed the economic aspects of groundwater management). In most watersheds, however, there is joint use of surface and groundwater for irrigation and increasing attention is therefore being paid to the joint management of these water resources (Buras, 1963; Burt, 1964), given that "groundwater and surface are two components of a single system and must be managed jointly" (Masahiko and Tsur, 2007, p 540). In a simple static model of the joint use of these water sources, Tsur (1990) identified a specific value of groundwater in the context of variability in surface water. Subsequently, Tsur and Graham-Tomasi (1991) calculated a different value for groundwater in a dynamic context, which they called the buffer value of groundwater. This groundwater value was also analysed by Masahiko and Tsur (2007). In an attempt to address the complexity of the joint management of water sources, an innovative approach was developed by Cai (1999) for the Syr Darya basin in central Asia. It was a dynamic interannual model that included hydrological, economic, agronomic and institutional components in the analysis of sustainability issues related to water resources management. In their model developed for the Maipo River basin in Chile, Rosegrant *et al.* (2000) included the sensitivity of water management to flow variations, the cost of improved irrigation techniques and the salinity problem. Later, Albek *et al.* (2004) integrated climate change simulations into their model and calibrated it on the basis of past data.

The assessment of agricultural development policies is a central issue in various watershed models that have been developed (Cai and Wang, 2006; Pulido-Velázquez *et al.*, 2006; Ward *et al.*, 2006). Cai *et al.* (2003) evaluated the role of investment and the impact of taxes and subsidies on water allocation, and also determined the sensitivity of water allocation to the increased demand for water and to changes in water prices. Several studies have looked at water management sensitivity to strategies based on sharing this resource (Draper *et al.*, 2003; Jakeman and Letcher, 2003; Jenkins *et al.*, 2004; Letcher *et al.*, 2004).

Most studies conducted in Morocco about watershed management have focused on four watersheds: the Loukkos and Tadla watersheds (Elame and Farah, 2008), the Draa watershed (Heidecke and Heckelei, 2010) and the Souss-Massa watershed. Only the model developed for the Draa watershed has the dynamic capacity to conduct long-term simulations. It is based, however, on an agricultural unit being a single farm, which could negatively influence results because in any agricultural unit there might be several modes of access to irrigation water, as well as differences in the degree of access. The models for the three other basins are still at the elementary stage, with production systems not explicitly introduced. It is also worth noting that regional agricultural policies have not been a factor in research conducted at the national level on water resources management.

The study described here focused on developing a model for the Tadla sub-basin that takes account of differences among farms in terms of mode of access to irrigation water, within the context of current agricultural policy in Morocco.

## The Tadla sub-basin

The Tadla sub-basin covers an area of 320,000 ha. The usable agricultural part of this area is about 300,000 ha, including 124,600 ha under irrigation. The sub-basin is characterised by a semi-arid climate with a dry season from April to October and a wet season from November to March. The average temperature is 18 °C., with a maximum of 38 °C in August and a minimum of 3.5 °C in January. It is also characterised by irregular annual rainfall and very pronounced interannual variability. An analysis of rainfall in the Oum Erbia basin, which includes the Tadla sub-basin, showed a significant decline. In the 1935-80 period, annual rainfall ranged from 275 to 1,025 mm, but in the 1980-2008 period, it ranged from 175 to 625 mm (ABHOER, 2012). The water used for irrigation in the Tadla sub-basin comes mainly from surface water. The proportion of groundwater used in irrigation, however, is increasing in parallel with the overall decline in rainfall. Between 2003 and 2010, it increased by 6.28%, from 446 million m3 to 474 million m3 (ABHOER, 2012). The main river in the Tadla sub-basin is the Oum Er Rbia, one of the most important rivers in Morocco. With regard to groundwater, the sub-basin has three phreatic aquifers: Beni Amir, Beni Moussa and Dir, and two deep aquifers: Eocene and Turonian (ORMVAT, 2014). (Figure 1)

The study focused on three agricultural territorial units (ATUs) in the Tadla sub-basin. The ATUs used for this study were: Tadla plain (ATU 1), rainfed agricultural area – private groundwater pumping (ATU 2) and the Dir unit (ATU 3). This choice was based on both strategic and practical considerations. On the one hand, these ATUs are seen by regional decision-makers as homogeneous areas at the regional level with regard to climate, topography and hydro-agricultural planning. On the other, these regions have large-scale irrigation schemes covering 98,300 ha and have benefited from regional agricultural development projects that have addressed production valuation, spatial distribution, water scarcity, land status and the integration of agricultural chains.

## Structure of the proposed model

The study sought to develop an agro-economic model of water management at the Tadla sub-basin level based on the simulation of water flows, equilibrium equations of water supply and use, water flows at river nodes and the allocation of water resources. In addition to reflecting the dynamics of interaction between various components (hydrological, agronomic and economic), it aimed at predicting changes in irrigation water shadow price, land use, water consumption and agricultural profit under different scenarios with regard to water availability and water resource allocation policy in the Tadla sub-basin (Figure 2).

TADMOD is a nonlinear economic optimisation model that, given various constraints, can maximize an objective function reflecting a social use that can be value-added at the basin level, or any other function reflecting the preferences and choices of policy-makers. Once the objective function (Eq.1) and constraints functions have been specified, the calibration of the model is obtained using positive mathematical programming (Howitt, 1995).

$$Max\ VA = \sum_{A\_S}\left(\sum_{Ir\_Mo} VA\_PMP_{A\_S,Ir\_Mo}\right) \quad (1)$$

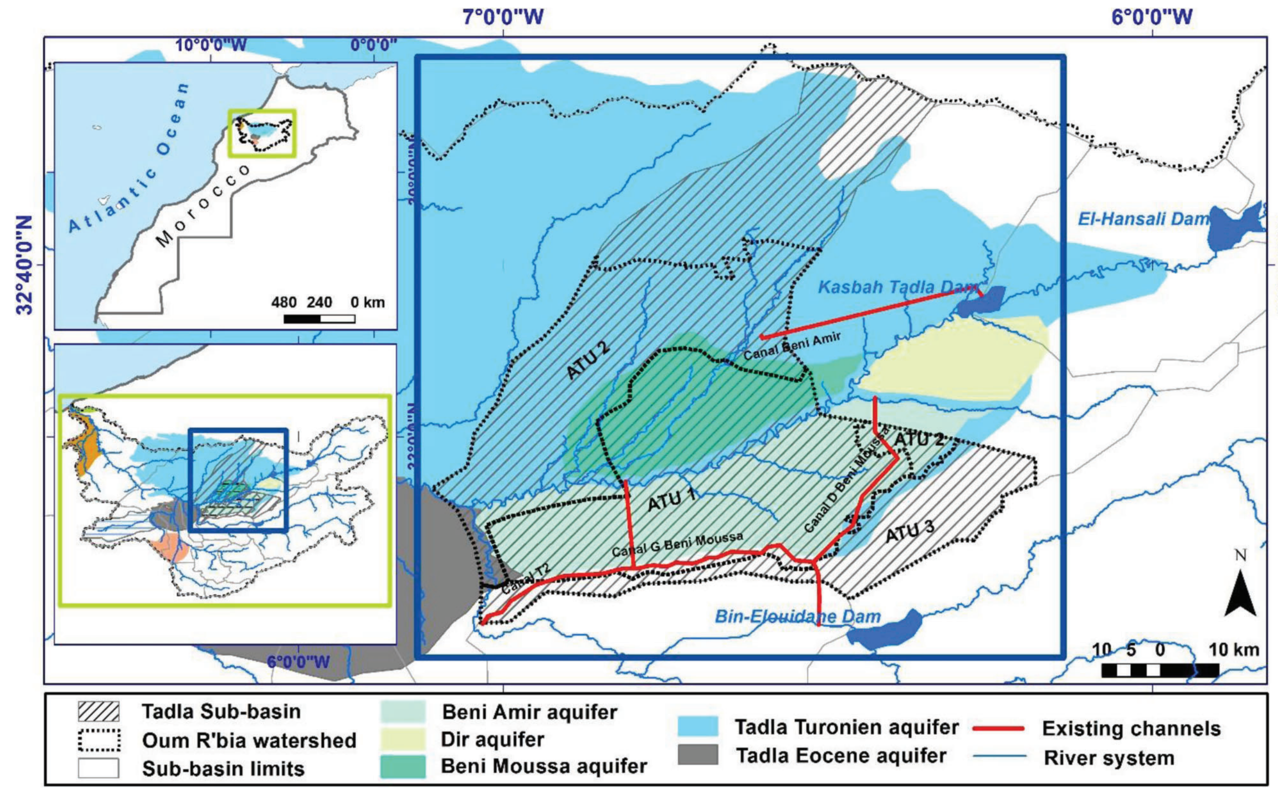


**Figure 1:** Tadla sub-basin

 

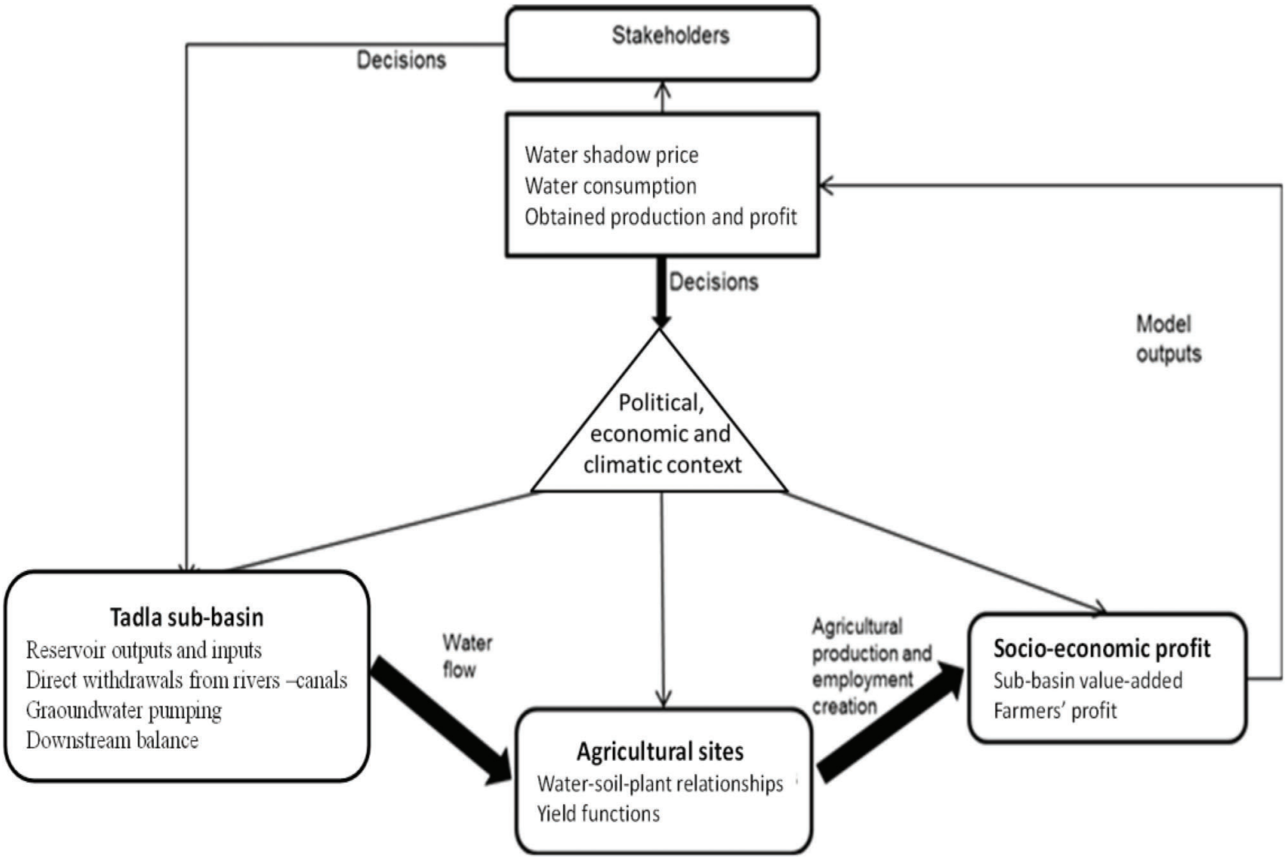


**Figure 2:** Structure of the TADMOD model for water management in the Tadla sub-basin

'Max VA' is agricultural net value-added at the basin level and 'VA_PMP' is the net value-added per agricultural site (sub-unit of the commune) and per irrigation system after calibration. 'A_S' is the agricultural site, referring to the sub-unit of the commune in order to differentiate modes of access in the same commune to existing irrigation water, 'Ir_Mo'. The net value-added per agricultural site and by mode of access to irrigation water is calculated from the output generated by the agricultural production system and the labour cost, minus costs of production and amortisation.

The Earth availability constraint is also taken into account in the model, so that the sum of cultivated areas by agricultural site 'CULT_AR' does not exceed the available area of arable land 'AR_LAND' in the Tadla sub-basin (Eq.2).

$$AR\_LAND \geq \sum\nolimits_{A\_S,Ir\_Mo,Crop} CULT\_AR_{A\_S,Ir\_Mo,Crop} \quad (2)$$

The initial land-use constraint refers to the part of each crop in the cultivated area by agricultural site and by mode of access to irrigation water. The marginal value of this constraint is used in the model calibration. The model optimizes the objective function on the basis of the observed values (Eq.3 and 4).

$$LAND\_USE_{A\_S,Ir\_Mo,Crop} = LAND\_USE\_Y0_{A\_S,Ir\_Mo,Crop} \quad (3)$$

$$LAND\_USE\_Y0_{A\_S,Ir\_Mo,Crop} = \frac{CULT\_AREA_{A\_S,Ir\_Mo,Crop}}{\sum_{Crop} CULT\_AREA_{A\_S,Ir\_Mo,Crop}} \quad (4)$$

'LAND_USE' defines the variable that determines the part of each crop in the total cultivated area, 'LAND_USE_Y0' refers to the part of each crop in the total arable area and 'CULT_AREA' is the parameter that indicates the area occupied by each crop in the reference year (2009-10).

In the Tadla sub-basin, water quantity used for irrigation ('WAT_USE') refers to water coming from dams and other surface sources ('SURF_WAT') and water pumped from aquifers ('GRD_WAT) (Eq.5).

$$\sum_{Crop} WAT\_USE_{A\_S,Ir\_Mo,Crop,PD} = SURF\_WAT_{A\_S,Ir\_Mo,PD} + \sum_{AQ} GRD\_WAT_{A\_S,Ir\_Mo,AQ,PD} \quad (5)$$

* **'A_S'**: agricultural site; **`Ir_Mo'**: mode of access to irrigation water; **'Crop'**: crop; **'PD'**: period (months); **`AQ'**: aquifer.

The crop yield functions in the model are designed as non-linear approximations of the ratio between the actual and maximum evapotranspiration based on the modified Penman function (FAO, 1998), whereby yield depends on the water demand per hectare.

In order to better reflect the complexity of operating conditions and the valuation of irrigation water in the medium term, TADMOD is being constructed as a 10-year recursive-dynamic model. The introduction of the dynamic element will be done by creating a set of years (10) and a loop. This loop will make iterations taking account of parameters and variables affected by the anticipated changes and introduced over the years. These changes relate to the rate of conversion to water-saving systems, crop extensions, rainfall trends, aquifer recharging and surface water inflows. For dams, the quantity of water remaining at the end of August will be used as the initial quantity for the following year, starting early September.

TADMOD will be sufficiently differentiated in terms of the physical and functional units of the basin (ATUs), commune, land use and mode of access to irrigation water. The model includes type of irrigation by including progressive rates of conversion to water-saving systems over 10 years for each land use. Crop extensions planned for future years under the Regional Agricultural Plan (PAR) were also included.

With regard to changes in water supply, we adopted a linear regression model with a time series of 50 years for the Tadla sub-basin, which shows a declining trend over the years.

The reference year chosen for this research was the 2009-10 crop year, from September to August, when the rainfall was about 475 mm (data obtained from the National Meteorology Direction).

TADMOD is an economic, agricultural and hydrological optimisation model, based on the actual relationship between the different nodes of the hydrological network. These nodes represent physical entities that could be influx, dams, aquifers or demand sites for agricultural water. Water distribution varies among the different agricultural demand sites (Lionboui *et al.*, 2014).

TADMOD is programmed in GAMS (Brooke *et al.*, 1998) and was resolved using the nonlinear solver CONOPT.

### Model database

The proposed agro-economic model requires very precise technical data and additional studies in the fields of hydraulics and agriculture. It also requires a detailed knowledge of the agro-hydraulic and economic system of water management in the Tadla sub-basin. These data are collected from regional bodies involved in irrigation water management, including the Office of Agricultural Development, the Provincial Direction of Agriculture, the Regional Direction of Agriculture and the Hydraulic Basin Agency of Oum Er Rbia River.

Working with agricultural development centres, surveys were conducted on crop rotation, standards for use of production factors and yields in relation to commune and to mode of access to irrigation water. In order to validate and complete the database, a survey of "agricultural farms" was conducted with farmers in the study area. The main crops grown in the ATUs studied are given in Figure 3.

The data collected were related to agronomic parameters, such as: yield per crop, production factor requirements, crop areas, effective rainfall, maximum evapotranspiration and the crop yield response coefficient. Data relating to technical and hydrological parameters were also collected, including: loss rate of agricultural water, water demand in relation to agricultural area and farm type, regulated volume and evaporation of reservoirs, and maximum volume, gradient, depth, permeability and storage coefficient of each aquifer. Socio-economic parameters were also considered for each agricultural area, including: agricultural production input prices, selling price of agricultural products, selling price of irrigation water, farm technical-economic efficiency rates and mode of access to irrigation water. In order to simulate interannual variations in economic and water management indicators, we also used data from agricultural development projects, including: rate of conversion to water-saving systems established through National Program of Irrigation Water Economy (NPIWE) projects, and projects focusing on crop expansion.

Understanding the diversity of production potential at the regional level requires designing a typology that enables farm types to be identified and classified. Previous work in the Tadla region on farmer strategies in water management and agricultural production contributed to building the typology for this study. In order to formalize the diversity of behaviour observed at the farm level, especially with regard to water management, we selected the typology described by Bacot (2001), based on access to water resources.

## 3. Results And Discussion

### Water shadow price

The shadow price of water is defined as the marginal increase in the value of the objective function (agricultural profit) if water availability is increased by an additional cubic meter. This shadow price reflects the scarcity of water resources, unlike the financial price. It is therefore among the most important values calculated by TADMOD because it enables the economic value of water in each agricultural site to be assessed (Table 1).

The TADMOD results show heterogeneity in the shadow price values within the same ATU. This illustrates the fact that farmers do not have for the same degree of access to irrigation water. The average shadow price of irrigation water calculated after calibration for the Tadla sub-basin was in the range of 1.33 MAD per cubic meter of water. It varied from an average of 1.19 MAD/m$^3$ for farms in ATU3 to 1.40 MAD/m$^3$ for those in ATU1.

In ATU1, the surface water selling price was 0.32 MAD/m$^3$. The difference between this value and the shadow price (1.40 MAD/m$^3$) can be explained by the irregularity of surface water supplies through the irrigation system channels coming from the Ahmed El Hansali and Bine Elouidane dams. In addition, some farmers reported that they received irrigation water at inappropriate times, thereby increasing its value.

In ATU2, the average cost of extracting groundwater is estimated to be 0.60 MAD / m$^3$, according to the Regional Direction of Agriculture. The average shadow price of water calculated for this zone, however, is 1.25 MAD/m$^3$. In the medium term, farms in this region do not suffer from water availability problems because there is private groundwater pumping. This value, however, is mainly because farmers invest in high-value crops.

For ATU3, irrigation water is private property and those holding the rights to it can sell it. According to the Provincial Direction of Agriculture, the water selling price here is 0.22 MAD/m$^3$, which is significantly lower

 

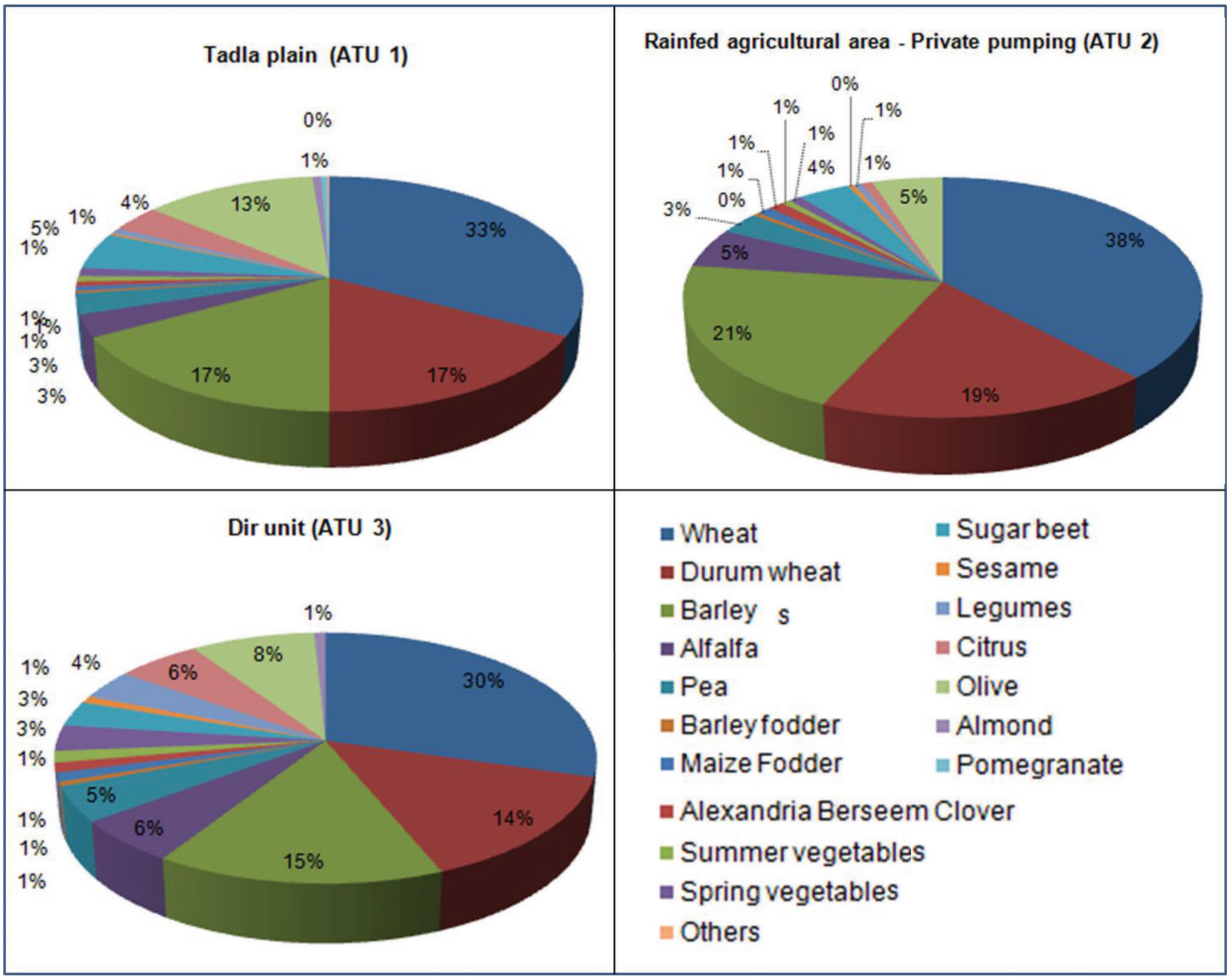


**Figure 3:** Observed crop share in the different agricultural territorial units (ATUs) of the Tadla Sub-basin in the reference year (2009-10)

**Table 1:** Frequency distribution of irrigation water shadow price values in the observed agricultural territorial units (ATUs)

| Classes (in MAD) | Agricultural territorial units (ATU) | | | | | |
|---|---|---|---|---|---|---|
| | ATU 1 | | ATU 2 | | ATU 3 | |
| | % | % cumulative | % | % cumulative | % | % cumulative |
| **0.00 – 0.50** | 3.64 | 3.64 | - | - | - | - |
| **0.51 – 1.00** | 41.81 | 45.45 | 40.00 | 40.00 | 31.23 | 31.23 |
| **1.01 – 1.50** | 20.00 | 65.45 | 26.67 | 66.67 | 56.27 | 87.50 |
| **1.51 – 2.00** | 29.10 | 94.55 | 33.33 | 100.00 | 12.5 | 100.00 |
| **⩾ 2.01** | 5.45 | 100.00 | - | 100.00 | - | 100.00 |
| **Average** | 1.40 | | 1.25 | | 1.19 | |
| **Standard deviation** | 0.59 | | 0.44 | | 0.36 | |

than the estimated shadow price (1.25 MAD/m$^3$ on average) and does not reflect its true value.

In terms of the interannual variation in irrigation water shadow price, Figure 4 shows the trend for this indicator, obtained by simulating the 10 years after the reference year (from 2010-11 to 2019-20). The figure takes into account the conversion and extension projects under PAR and water supply forecasts for the basin based on data from the Hydraulic Basin Agency.

In the years after the reference year, the water shadow price is predicted to increase by 33.2% and might therefore reach 1.70 MAD/m$^3$ in 2019-20 (Figure 4). This confirms the results obtained by Heidecke *et al.* (2008) in a study conducted in a similar context on decreasing water resources. This is linked to the expected decrease in water resources in the Tadla sub-basin, making irrigation water a production-limiting factor. It is also linked to the programmed intensification projects.

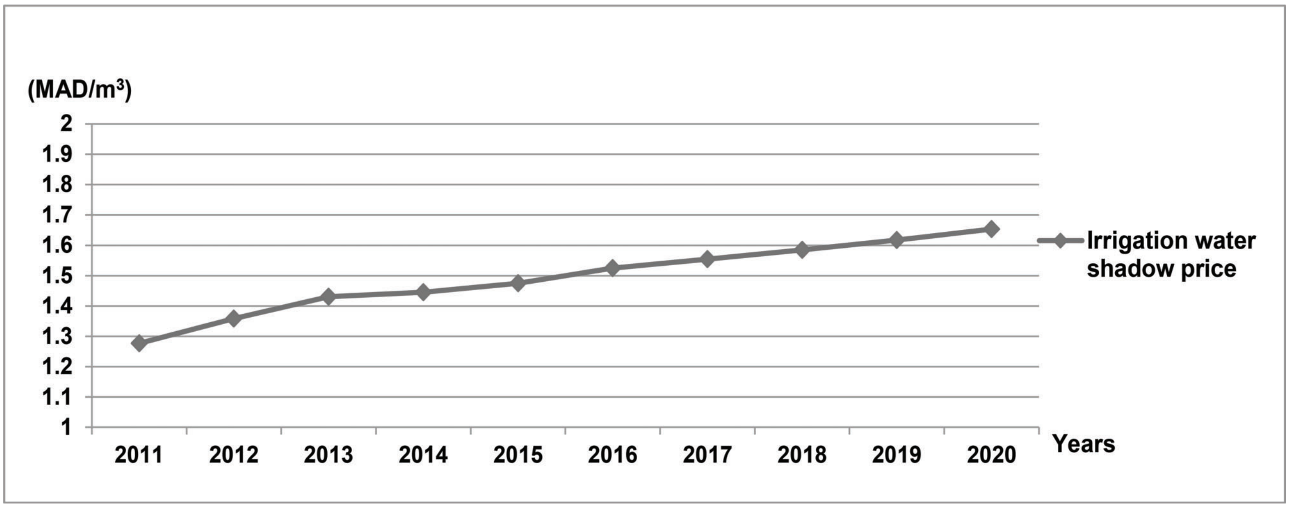


**Figure 4:** Predicted changes in the irrigation water shadow price in the Tadla sub-basin by TADMOD

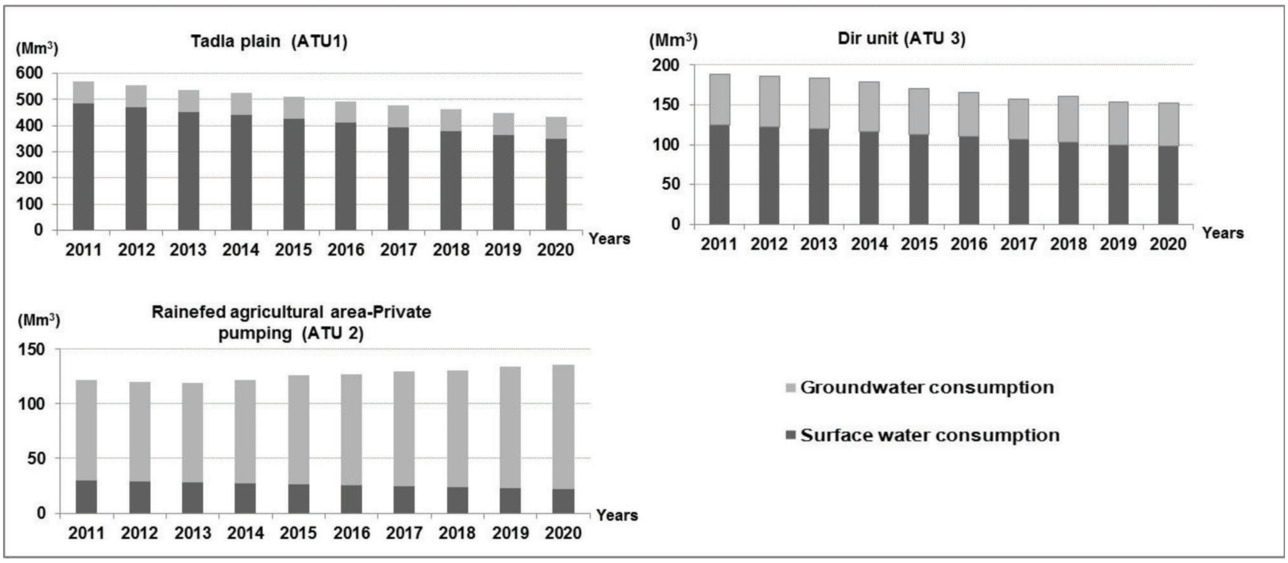


**Figure 5:** Predicted changes in water consumption in the agricultural territorial units (ATUs) in the Tadla sub-basin

## Changes in irrigation water consumption in the Tadla sub-basin

The total surface water consumption across the Tadla sub-basin is about 638.18 million m$^3$, of which ATU1 consumes 75.45%. Groundwater accounts for the rest of the irrigation water consumption here, with a volume of 265 Mm$^3$, of which 45.46% is consumed in ATU2.

The change in the irrigation water consumption indicator over the simulated years is shown in Figure 5.

From the 2010-11 crop season through to the 2019-20 season, the total consumption of irrigation water in ATU1 and ATU3 will decrease, particularly in the case of surface water. The volume of water consumed by farms is directly related to the payed fee, which enables them to receive a price signal that encourages them to adopt water conservation practices. Under current agricultural policies, subsidies and outreach programs are being used to encourage the adoption of water-saving systems in order to cope with the expected reduction of surface water inflows in the Tadla sub-basin.

In ATU2, irrigated mainly by groundwater, water consumption will increase slightly. This reflects the increase in the number of wells and boreholes being constructed in this area, as reported by Hamani and Kuper (2007). Encouraged by the availability of groundwater throughout the year, farmers in ATU2 are now diversifying and intensifying their agriculture, thus putting a larger area under crops with high added value, whatever their water consumption.

## Cropping system

The reduction in water inflows in the Tadla sub-basin will reduce the cultivated area by 1.90%, from 334,347.58 ha in 2010-11 to 328,177.11 ha in 2019-20. For the three ATUs selected for this study, cropping plans will vary during the simulated years. These changes are shown for each ATU in Table 2.

The declining availability of water in the Tadla sub-basin will lead farmers to opt for crops that require less water, but offer good margins, in order to maximize their profits. There is therefore likely to be an increase in the area allocated to tree crops, sugar beet and vegetables at the expense of cereal and forage crops.

 

**Table 2:** Crop share variation in the Tadla sub-basin

| | share% Crops | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ATU1** | Cereals | 63.90 | 63.30 | 62.59 | 61.96 | 60.97 | 60.56 | 60.16 | 59.76 | 59.31 | 58.92 |
| | Forage | 12.09 | 12.05 | 11.97 | 11.77 | 11.77 | 11.77 | 11.78 | 11.78 | 11.79 | 11.81 |
| | Vegetables | 2.04 | 2.11 | 2.18 | 2.20 | 2.27 | 2.34 | 2.41 | 2.47 | 2.54 | 2.62 |
| | Sugar beet | 4.89 | 4.89 | 4.89 | 6.03 | 6.04 | 6.06 | 6.07 | 6.08 | 6.09 | 6.10 |
| | Citrus | 3.45 | 3.46 | 3.46 | 3.44 | 3.45 | 3.47 | 3.48 | 3.49 | 3.51 | 3.53 |
| | Olive | 12.10 | 12.70 | 13.46 | 13.59 | 13.88 | 14.17 | 14.46 | 14.75 | 15.04 | 15.34 |
| | Other | 1.04 | 1.05 | 1.05 | 1.04 | 1.05 | 1.06 | 1.08 | 1.09 | 1.10 | 1.10 |
| | Legumes | 0.35 | 0.35 | 0.36 | 0.33 | 0.33 | 0.34 | 0.35 | 0.35 | 0.36 | 0.36 |
| **ATU2** | Cereals | 83.60 | 83.17 | 82.63 | 82.04 | 81.85 | 81.65 | 81.29 | 80.80 | 80.58 | 80.36 |
| | Forage | 1.26 | 1.25 | 1.24 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| | Vegetables | 1.36 | 1.37 | 1.39 | 1.36 | 1.37 | 1.39 | 1.40 | 1.41 | 1.43 | 1.45 |
| | Sugar beet | 3.12 | 3.13 | 3.14 | 3.69 | 3.66 | 3.65 | 3.64 | 3.62 | 3.62 | 3.62 |
| | Citrus | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 1.17 | 1.47 | 1.49 | 1.50 |
| | Olive | 7.07 | 7.47 | 7.98 | 8.11 | 8.29 | 8.46 | 8.62 | 8.79 | 8.96 | 9.13 |
| | Other | 0.93 | 0.94 | 0.96 | 0.98 | 1.00 | 1.01 | 1.03 | 1.05 | 1.05 | 1.05 |
| | Legumes | 1.67 | 1.68 | 1.68 | 1.61 | 1.62 | 1.63 | 1.63 | 1.63 | 1.64 | 1.65 |
| **ATU3** | Cereals | 53.21 | 51.70 | 49.88 | 48.58 | 47.41 | 46.26 | 45.42 | 44.76 | 44.18 | 43.59 |
| | Forage | 5.77 | 5.73 | 5.70 | 5.56 | 5.55 | 5.55 | 5.55 | 5.54 | 5.55 | 5.56 |
| | Vegetables | 5.75 | 5.72 | 5.66 | 5.44 | 5.36 | 5.25 | 5.17 | 5.14 | 5.17 | 5.20 |
| | Sugar beet | 2.60 | 2.56 | 2.51 | 3.07 | 3.07 | 3.07 | 3.07 | 3.07 | 3.07 | 3.07 |
| | Citrus | 6.08 | 6.50 | 6.91 | 7.74 | 8.54 | 9.35 | 9.81 | 9.98 | 9.95 | 9.92 |
| | Olive | 22.08 | 23.33 | 24.98 | 25.45 | 25.97 | 26.49 | 27.02 | 27.55 | 28.08 | 28.62 |
| | Other | 2.22 | 2.22 | 2.19 | 2.11 | 2.12 | 2.12 | 2.12 | 2.14 | 2.18 | 2.21 |
| | Legumes | 2.28 | 2.24 | 2.18 | 2.05 | 1.98 | 1.91 | 1.84 | 1.81 | 1.82 | 1.83 |

**Table 3:** Value-added in the observed agricultural territorial units (ATUs)

| | ATU1 | ATU2 | ATU3 |
|---|---|---|---|
| Value-added /year (millions MAD/year) | 1826.54 | 857.85 | 496.39 |
| Value-added /ha (MAD/ha) | 17231.48 | 5098.10 | 7263.69 |
| Cultivated area (ha) | 106000 | 168272 | 68339 |
| Irrigated area (ha) | 98300 | 42100 | 24514 |
| Non-irrigated area rainfed agriculture" (ha) | 7700 | 126172 | 43825 |

## Agricultural value-added

TADMOD maximizes value-added agriculture in the Tadla sub-basin. Unlike the gross margin, which reflects the enrichment of individual producers, value-added measures the wealth creation for the community as a whole (including labour income). It represents the sum of labour remuneration, financial expenses and taxes or subsidies, as well as a producer's gross margin. The average value-added calculated for the Tadla sub-basin is 3,180.78 million MAD/year, with an average per hectare of 9,513.40 MAD. The value-added in terms of each ATU is presented in Table 3.

Table 3 shows the differences between the ATUs in terms of their value-added per hectare. ATU1 has a higher value-added by hectare, on average (17,231.48 MAD/ha). In this unit, 92.74% of the cultivated land has access to irrigation water and farmers obtain high yields. For ATU2 and ATU3, mostly non-irrigated farmland, the value-added is 5,098.10 and 7,263.69 (MAD/ha), respectively. These units are entirely dependent on rainfall, which varies in amount from one year to the next and directly affects crop yields. Farmers here therefore prefer not to invest excessively in these lands, in order to avoid the risks associated with drought.

Based on the TADMOD results, the value-added in the Tadla sub-basin will decrease slightly during the simulated years (Figure 6).

The average value-added calculated for all to the ATUs in the Tadla sub-basin will fall from 3,180.78

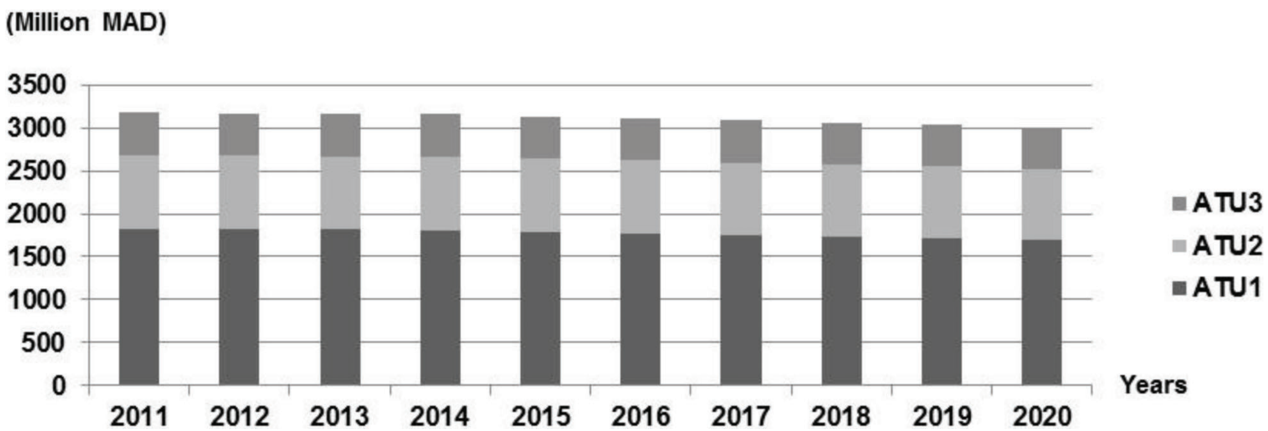


**Figure 6:** Changes in the total value-added in the Tadla sub-basin over 10 years

million MAD in the first year to 3,009.96 million MAD in 2019-20. This decrease will occur mainly because the cultivated area will decrease as a result of the predicted reduction in irrigation water supplies over this period.

## 4. Conclusion

Within the context of a predicted downward trend in annual water inflows, this study provided an update on the situation and analysed the interannual variation in the shadow price of water, the use of irrigation water and farmland, and value-added agriculture in the Tadla sub-basin. This was done by using TADMOD, a dynamic agro-economic model that classified ATUs according to their different sources of irrigation. An irrigation typology was included in the model based on rates of conversion over 10 years for each land use. Crop extensions planned for future years as part of PAR were also considered.

Among the most important results of this study were those related to the shadow price of irrigation water, which helped in assessing the economic value of water at each agricultural site in the studied ATUs. An analysis of the reference year (2009-10) showed important differences in water shadow price among agricultural sites. The average value of the shadow price calculated by TADMOD for the Tadla sub-basin was about 1.33 MAD/m$^3$ of water. This value was much higher than the real selling price of water in the ATUs at the time. The shadow price of irrigation water varied from 1.19 MAD/m$^3$, on average, for ATU3 sites to 1.40 MAD/m$^3$ for ATU1 sites. In the 10 years after the reference year, the shadow price of water is going to increase by 33.2%, which may require a revision of irrigation water tariffs in the region. The total consumption in surface water is going to decrease, whereas groundwater consumption will increase slightly to compensate for the scarcity of surface water, as there are no restrictions on groundwater extraction.

The reduction in water inflows in the Tadla sub-basin will also result in a slight decrease (about 1.9%) in the cultivated area, falling from 334,347.58 ha in 2010-11 to 328,177.11 ha in 2019-20. This reduction in cultivated area will encourage farmers to opt for crops that require less water, but offer good margins, in order to maximize their profits. The total value-added of agricultural products generated in the Tadla sub-basin will decrease slightly, mainly because of the reduction in cultivated areas related to the reduced irrigation water supply levels expected during this period.

Finally, this research aimed at providing a scientific approach and an applied tool to control water management and adopt the most appropriate agricultural policies. This operational management tool could lead to help the decision-makers and stakeholders to adopt an efficient irrigation water management at the sub-basin level.

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REFEREED ARTICLE

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# High rates of regular soil testing by Irish dairy farmers but nationally soil fertility is declining: Factors influencing national and voluntary adoption

E. KELLY[1], K. HEANUE[2], C. O'GORMAN[3] and C. BUCKLEY[2]

**ABSTRACT**

Paradoxically, high rates of soil testing by Irish dairy farmers coexist with declining national soil fertility levels. This study investigates the anomaly further through identifying the characteristics of farms and farmers who regularly test soil in terms of policy, education, financial capacity, networks, and land-management practices. The study draws on data from a nationally representative sample of 231 specialist Irish dairy holdings. As policy mandates the use of soil tests for some farmers, a sub-sample of non-mandated farms is analysed separately. Findings comparing testers and non-testers show all farmers testing their soil on a regular basis are younger, have larger farms and herds, have larger gross output, have greater expenditure on nitrogen, and are more profitable, compared to farmers who do not. The analysis also shows nationally there is no significant difference in fertilizer and concentrate expenditure per hectare between soil test users and non-users, also reflected in the sub-sample. The logit regression analysis of the full sample suggests policy and extension programmes have a significant effect on adoption, however given national falling soil fertility trends farmers may not be using the results to achieve optimal outcomes. For the voluntary sub-sample farmers who attended part-time education courses and improved farmland through reseeding are more likely to regularly soil test. These findings are important in the context of the somewhat contradictory environmentally-focused and productivity-focused policy instruments that drive regular soil testing behaviour and the anomaly of high rates of soil testing with declining national soil fertility levels.

**KEYWORDS:** policy; legislation; soil fertility; voluntary use

## 1. Introduction

### Soil testing and farm practice

Soil testing is a key, though not sufficient, tool for improving soil fertility, as the information generated from a soil test report must be implemented or translated into action via nutrient management practices for soil fertility improvements to occur. An improved understanding of the translation of scientific results to practical implementation may require examination of farmer nutrient management practices and soil fertility at a micro level. The research reported here is the first part of a larger social science-based mixed methods research project of Irish dairy farmers' use of soil test information (Kelly, 2014). The empirical context for the project is the anomaly in Ireland between high levels of soil testing (71%) and declining trends in soil fertility. The larger project seeks to understand the process involved after a soil test is carried out on a farm, how that information is used in subsequent decisions together with other knowledge, and how the resulting actions impact soil fertility levels. Given the lack of prior research in an Irish context, this paper on explores the characteristics of Irish dairy farmers who regularly soil test.

Theoretically farmers test soil to assess its fertility with a view to matching nutrient supply with crop demand, thereby maximising production and profitability while also reducing the risk of nutrient transfer to the wider atmospheric and aquatic environment. The two main functions of soil testing, to determine soil nutrient status and soil pH value (Gallagher & Herlihy 1963), enables farmers to optimally manage the nutrients in their soil in terms of soil fertility and crop return. Achieving a balanced pH in soil ensures the efficient uptake of the

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major nutrients. Nutrients to enhance soil fertility for crop production are applied on farms in two main forms, organic[4]and inorganic. However, as soil is permeable, inappropriate application of nutrient in terms of volumes or timing may increase the risk of nutrient transfer from agricultural land to the aquatic environment. Soil testing is an established practice and has the potential, from a policy perspective, to deliver a double dividend of increased economic returns to agricultural production while helping to achieve environmental objectives in line with international commitments under the EU Nitrates Directive[5], the Water Framework Directive[6], the Kyoto Protocol agreement and EU 2020 targets to reduce greenhouse gas emissions. Soil testing is also considered a cost positive practice[7]: generally soil testers should save money through improved management of required inputs, specifically expenditure on chemical fertiliser or through spatially efficient use of nutrients at farm level.

### The Irish Context

Ireland's temperate climate generates high yields in arable crops and ideal conditions for grass-based production which is the key input to low-cost milk production systems. This presents a comparative advantage to Irish dairy farmers compared to competing countries who tend to rely more heavily on concentrate feed usage. A challenge for Irish dairy farmers is to increase productivity in a sustainable manner (Culleton, 2013).

The index system for assessing soil nutrient availability across the Republic of Ireland ranges from 1-4[8]. These data are Teagasc[9]samples currently available at national level and not for farm-level modelling due to confidentially. It is only possible to assess trends nationally, regionally and by sector. In the 1950s soil fertility was very poor in Ireland, with over 90% of soil samples taken by Teagasc recording phosphorus and potassium levels at very low (index 1) levels, however this had reduced to 44% and 29% respectively by 1960 (Coulter, 2000). This positive trend, which continued into the following decade, may have been related to improved nutrient management practices and the productivist focus of Common Agricultural Policy (CAP) instruments. More recent trends over the period 2001-2011, however, show that the proportion of soils classified as having very low (index 1) and low (index 2) fertility levels have increased from approximately 15% to 55% overall, steadily increasing since 2007. In 2011 only 25% were at the optimum index (Plunkett, 2012). The greatest increase in this trend has been from 2009-2012 with increasing numbers of samples (peaks: 59% (P) and 54% (K)) in the low categories. This trend is reasonably consistent across all sectors and regions (Donnellan, Hanrahan & Lalor 2012; Wall *et al.* 2015).

[4] Commonly referred to as slurry or farmyard manure, the material contains mainly dung and urine potentially waste water (washings) collected in large tank at farm yards during periods of animal housing (winter). It is applied onto fields during the growing season excluding the closed period as stipulated by the nitrates directive.

[5] European Council, 1991.

[6] Official Journal of the European Community, 2000.

[7] Two exceptions exist. On nutrient surplus farms costs may be incurred in exporting excess nutrients and secondly on nutrient deficient farms, where increased inputs are required (Beegel *et al.* 2000).

[8] Developed by Teagasc Johnstown Castle (Conway 1986) and refined and changed over time. For a detailed report on changes in soil advice and management in Ireland see Coulter (2000). Since then, field studies (Schulte & Herlihy 2007) and a review (Schulte & Lalor 2008) have led to further changes in the parameters (Coulter & Lalor 2008).

[9] The Irish Agriculture and Food Development Authority.

Declining soil fertility could reflect the introduction of increasingly stringent EU legislation and guidelines regarding on-farm nutrient use, with declining trends in fertiliser sales over the period 2001-2011 (Donnellan, Hanrahan & Lalor 2012). Fertiliser prices also accelerated over the same period peaking in 2008; with a decline in 2009 and 2010, but increasing in 2011, raising concerns regarding the volatility of this input price (Breen *et al.*, 2012, Buckley *et al.,* 2016). The declining trend in soil fertility over this period raise questions for policy makers regarding legislative obligations placed on farmers to test soil. Policy instruments which mandate use of soil testing have conflicting objectives, for example to increase soil productivity under agri-environment schemes such as the Rural Environmental Protection Scheme (REPS) and to restrict nutrient application use under the EU Nitrates Directive (91/676/EEC), yet both aim to achieve improved soil fertility levels which are agronomically and environmentally optimal. A soil test is compulsory for farmers in REPS and for farmers operating under derogation from the Nitrates Directive. The quantity of organic nitrogen applied on farms is limited to 170kg per hectare, increasing with a derogation to 250kg per hectare under the EU Nitrates Directive. Outside of the aforementioned groups, soil testing by Irish farmers is on a voluntary basis.

## 2. Understanding Farmers Adoption Decisions

Much of the literature on soil testing and conservation relates to tillage farms, focusing on binary adoption decisions. The classic work of Rogers (1962) examined the diffusion of innovations over time focusing on three factors: antecedents (population variables: needs, problems, and the social system), the process in terms of knowledge (characteristic of the decision-making unit) and persuasion relating to the innovation (relative advantage, compatibility, complexity, trialability and observability), the final decision stage is where ultimately there is continued or discontinued, adoption or rejection at the confirmation stage, with lesser focus on implementation. The body of research focuses on the decision to adopt or reject a technology with an overarching focus on the speed of the decision process (early adopters, early majority, late majority, laggards) (Rogers, 2003). There is some agreement on the explanatory variables that predict technology adoption in agriculture notwithstanding inconsistencies in research approaches and measures used (Baumgart-Getz, Prokopy & Floress, 2012). For example, the 'ADOPT'[10] model (Kuehne *et al.,* 2013) incorporates research evidence on technology adoption to predict peak adoption levels and timing to reaching peak adoption. The model is based on variables relating to the population in terms of characteristics or orientation and available supports for the population such as the opportunities to learn about the innovation. The model accounts for the characteristics of the innovation itself, the relative advantage of using the innovation and possible experimental learning and use. The ADOPT elements are reflective of a broad adoption literature across a range of contexts. In the literature a range of variables are used including

[10] The Adoption and Diffusion Outcome Prediction Tool.

**Table 1:** Variables used in models

| Variable | Explanatory Variables | Note on variables | Hypothesised |
|---|---|---|---|
| 1 | Dairy Platform | Area of grassland devoted to dairy herd | + |
| 2 | Soil Quality | Soil with wide range use =1 | - |
| | | Soil with moderate range use =2 | |
| | | Soil somewhat limited range use =3 | |
| | | Soil limited or very limited range use =4 | + |
| 3 | FarmGM/UAA | Farm Gross Margin Euro per UAA (Utilizable agricultural area) | + |
| 4 | Cashflow | Having a cashflow budget: binary | + |
| 5 | Formal Agricultural Education | Having formal agricultural training (categorical)Full time third level/Farm Apprenticeship scheme/Certificate in farming/Year in Agricultural college=1 | + |
| | | Part time course (<60 hours & >60 hours/other)=2 | |
| | | No formal agricultural education=0 | |
| 6 | Discussion Group Membership | Participation in groups are the main knowledge tool support best practice to farmers: binary | + |
| | Grass covers | Conducting grass covers estimate quality of herbage matter in paddock: binary | |
| 7 | Reseeding | Farm reseeded in past three years: binary | + |
| 8 | REPS/Derogation* | Participation in environmental scheme: binary | + |

* REPS/Derogation participant were excluded from the voluntary model

resources, size and scale, human capital, farmer characteristics, skills and knowledge and potential constraints such as availability of information (risk), time and costs of adoption (credit availability) (Griliches, 1957; Feder, Just & Zilberman 1985; Feder & Umali 1993; Khanna, 2001; Rogers, 2003). Attitudinal factors, networking capacity and understanding structural and institutions differences are seen as increasingly important (Knowler & Bradshaw 2007; Prokopy *et al.,* 2008; Fischer & Qaim, 2014). Elsewhere, Baumgart-Getz, Prokopy & Floress (2012) synthesise three groups of explanatory variables: quality of information, financial capacity and networks, which in broad terms have the largest impact on adoption. As soil testing is a well-established practice, with high rates of adoption among Irish dairy farmers, variables selected in this paper align with these three groups of variables, to identify the likelihood of adoption based on characteristics rather than timing and saturation.

To capture the mandated effect, those more likely to adopt in a voluntary capacity, a sub-sample of voluntary users is considered in this paper. Two conflicting motivations may exist for voluntary users: (a) increasing production or (b) reducing the negative impact, environmental and/or economic, of inappropriate fertiliser application. The objective of this paper is to identify the cohorts of farmers who are more or less likely to soil test on a regular basis, for both the national sample and a sub-set of farmers who test in a voluntary capacity. Two research questions are addressed for each sample. First, to test what, if any, economic and structural differences exist between soil test users and non-users? Second, what are the farm and farmer characteristics of Irish dairy farmers who soil test on a regular basis?

## 3. Methodology

### Data

Data were collected using the Teagasc National Farm Survey (NFS) which is a nationally representative weighted sample of farms in the Republic of Ireland (Connolly, 2010). The NFS is collected annually as part of the Farm Accountancy Data Network (FADN) requirements of the European Union (FADN, 2013). Collectively these data contain information relating to farm activities, financial returns to agriculture and demographic characteristics. Specialist dairy farms, defined as systems where at least two-thirds of farm standard output is from grazing livestock and where dairy cows are responsible for at least three-quarters of the grazing livestock output, are analysed in this paper based on 2009 NFS data. Standard output (economic based measures) are applied to each animal and crop output on the farm and only farms with a standard output of €8,000 or more (the equivalent of 6 dairy cows) are eligible for inclusion in the sample.

The sample of 231 specialist dairy farmers is representative of approximately 14,000 specialist dairy farms nationally. Table 1 lists and provides an explanation of all variables used in the regression analysis. The binary dependent variable in this model takes a value of one for farmers who conduct a soil test on a regular basis and value of zero if they do not. In total thirteen explanatory variable were considered in this analysis. The explanatory variables selected are based on the broad variable groups identified by Baumgart-Getz, Prokopy & Floress (2012) which have the largest impact on adoption: quality of information (education), financial capacity (farm gross margin, cashflow) and networks (discussion group membership) and two land-management practices (reseeding and grass covers). Grass covers and discussion group membership initially considered as independent are considered collectively in the final model as an interaction term given the strong association between membership and conducting covers. Two context specific variable were also considered, soil quality and policy instruments which mandate soil testing in Ireland. The soil quality[11] variable represents four categories of soil use classification. The policy variable selected represents farms who participate in the REPS scheme or those who have applied for a derogation under the nitrates directive. The remaining explanatory variables considered relate to farm characteristics (dairy platform, age, expenditure on lime and fertiliser per hectare and stocking intensity).

[11] The soil quality variable used in this analysis is a soil use classification variable based soil capacity (Gardner & Redford, 1980) based on six classifications of Irish soils. Soil use class 1 identifies soils with potential to grow the widest range of crops without limitation while soil use 6 have extremely limited use range. Only 5 categories were represented in this sample with no farm classified as category 6. Category 4 (limited use) and category 5 (very limited use) were combined due to the small numbers of farms in category 5 (n=12). This is as expected due to the nature and intensity of specialist dairy farming.

 

**Table 2:** National Sample of Specialist Dairy Farmers

| Variable | All n=231 Mean (StdDev) | Regular Soil Test Users n=165 Mean (StdDev) | No regular Soil Test n=66 Mean (StdDev) | T test p-value |
|---|---|---|---|---|
| Age | 50 (10) | 48.7 (10) | 53.4 (11) | **0.00** |
| Farm Size | 57.6 (31) | 60 (28) | 49.1 (36) | **0.00** |
| Dairy Grazing Platform | 33.8 (18) | 36.8 (19) | 26.3 (14) | **0.00** |
| Size of Dairy Herd (Avg) | 64.1 (36) | 68.9 (36) | 52.1 (34) | **0.00** |
| Farm Gross Margin (GM) (€)/UAA | 1227.48 (476) | 1292.5 (468) | 1064.87 (460) | **0.00** |
| Farm Gross Output (GO) (€)/UAA | 2203.9 (754) | 2295.7 (770) | 1974.29 (664) | **0.00** |
| Nitrogen (Kg)/UAA | 100 (51) | 105 (53) | 87.7 (44) | **0.02** |
| Grazing Days | 227.1 (26) | 229 (24) | 222.3 (24) | **0.08** |
| Direct Cost(€)/UAA | 976.4 (426) | 1003.2 (446) | 909.4 (367) | **0.13** |
| Fertiliser(€)/UAA | 164.8 (67) | 168.6 (69) | 155.2 (60) | **0.17** |
| Concentrates(€)/UAA | 344.8 (210) | 351.4 (217) | 328.3 (192) | **0.45** |
| Stocking Density | 1.86 (0.50) | 1.87 (0.486) | 1.85 (0.49) | **0.75** |

**Table 3:** Logit Model One National Sample of Specialist Dairy Farmers

| Explanatory Variable | Estimated Coefficient Standard Error (SE) | Odds Ratio (êb) | 95% CI |
|---|---|---|---|
| REPS/Derogation | 2.52*** (0.40) | 12.37 | [1.73 3.29] |
| Discussion group and grass cover | 2.00** (0.82) | 7.39 | [0.40 3.60] |
| Reseeding | 0.919** (0.42) | 2.51 | [0.10 1.74] |
| Dairy Platform | 0.04** (0.02) | 1.04 | [0.01 0.07] |
| Log pseudo likelihood -95.09 Pseudo R2 0.358 | | | |

Number of observations is 231. * $p<0.1$, ** $p<0.05$, *** $p<0.001$

The latter three variables are dropped from the analysis due to collinearity (expenditure on lime and fertiliser, intensity are highly correlated with farm gross margin). Gross margin is theoretically preferred variable for comparability with broader literature. Age was also dropped from the analysis as it is highly correlated with education. Education is a preferred variable based on the policy implications. The final population model contains eight variables with the policy variable redundant for the voluntary model.

## Models

The study is based on two groups of specialist dairy farmers: the sample (n=231) and a voluntary sub-sample (n=86) of farmers not mandated to soil test. The latter group excludes REPS participants and derogation farmers. Scale and income variables (dairy platform[12], farm gross margin, cashflow) are hypothesised to have a positive impact on adoption (Prokopy *et al.,* 2008). The hypothesised relationship between adoption and soil quality varies with soil type. Wide ranging use soils are hypothesised to have a negative relationship on adoption while soils with limited range use soil classifications hypothesised to have a positive relationship (Khanna, 2001) although anecdotally it is thought better soils tend to support more productive orientated farmers who are more likely to test regularly.

Participation in agri-environmental schemes (REPS), used in the population model, is hypothesised to have a positive impact on adoption as is education and participation in extension networks (discussion groups) (Hennessy & Heanue, 2012) reflecting quality of information received. Discussion groups also promote the use of practices complementary to soil testing (grass covers) and other associated practices (reseeding). Conducting a grass cover is included as an interaction term with discussion group membership as main focus of the groups is to promote grassland management. Farmers who conduct these practices are likely to be concerned with increased productivity of grass and, therefore, soil fertility, both variables are hypothesised to have a positive relationship with likelihood of soil testing.

Tables 2 and 4 show descriptive statistics and two sample t-tests[13], testing if there is a statistically significant difference between adopters and non-adopters, for all model variables, addressing the first research question, examining the economic and structural differences for two independent groups. The results for the full sample (Table 3) and voluntary sub-sample (Table 5) address the second research question. Logit models are used to identify the probability that individuals with certain characteristics are likely to be in the regular testers group or not.

Given the dichotomous nature of the decision to soil test, the model is non-linear with a cumulative distribution function, with the estimated conditional probabilities between zero and one. The relationship between the probability (Pi) and the variable (Xi) is non-linear. This requires a non-linear functional form. The model fit is estimated by maximum likelihood (ML). The likelihood function indicates how likely it is that the data reflects the population parameters (Long & Freese 2006).

[12] Hectares of grazing allocated specifically for dairy cows.

[13] Null hypothesis assumes the difference between the groups is zero.

**Table 4:** Voluntary sub-sample of Specialist Dairy Farmers

| Variable | Sample n=86 Mean (StdDev) | Regular Soil Test Users n=39 Mean (StdDev) | No regular Soil Non Users n=47 Mean (StdDev) | T-Test p-value |
|---|---|---|---|---|
| Dairy Grazing Platform | 33.14 (20.1) | 42.7 (22.5) | 25.2 (13.7) | **0.00** |
| Size of Dairy Herd (Avg) | 61.4 (36.8) | 76.4 (32.7) | 49 (35.7) | **0.00** |
| Farm Gross Output(GO) (€)/UAA | 2043.9 (713.6) | 2266.3 (727.3) | 1859.2 (653.5) | **0.00** |
| Farm Size | 59.8 (38.8) | 72.5 (32.8) | 49.3 (40.6) | **0.01** |
| Farm Gross Margin (GM) (€)/UAA | 1121.1 (492.5) | 1263.8 (476.9) | 1002.7 (478.4) | **0.01** |
| Nitrogen (Kg)/UAA | 95.5 (50) | 111.2 (54) | 82.5 (42.8) | **0.01** |
| Grazing Days | 226.5 (28.7) | 234.2 (24.9) | 220 (30.4) | **0.02** |
| Age | 50.5 (12) | 47.6 (11.2) | 53 (12.2) | **0.04** |
| Fertiliser(€)/UAA | 163.5 (70.1) | 179.6 (78.7) | 150.2 (59.7) | **0.05** |
| Direct Cost(€)/UAA | 922.7 (369.0) | 1002.5 (384.6) | 856.5 (345.8) | **0.07** |
| Stocking Density | 1.82 (0.542) | 1.9 (0.514) | 1.76 (0.561) | **0.21** |
| Concentrates/UAA | 326.7 (188.7) | 337.5 (182.1) | 317.7 (195.5) | **0.63** |

**Table 5:** Logit Model Two Voluntary Sub-sample of Specialist Dairy Farmers

| Explanatory Variable | Estimated Coefficient Standard Error (SE) | Odds Ratio (êb) | 95% CI |
|---|---|---|---|
| Formal Ag. Training [category 2] | 2.03** (0.80) | 7.60 | [0 .45 3.60] |
| Reseeding | 1.28** (0.62) | 3.59 | [0.07 2.49] |
| Dairy Platform | 0.056** (0.02) | 1.06 | [0.02 0.10] |
| Log pseudo likelihood -2343.51 Pseudo R2 0.27 | | | |

Number of observations is 78. * $p<0.1$, ** $p<0.05$, *** $p<0.001$

The conditional expectation of $E(Y_i|X_i)$, can be interpreted as the *conditional probability* that the event will occur given $X_i$ as $\Pr(Y_i = 1|X_i)$, if $Y_i = 1$. The probability of an event occurring that is $P_i$ and the probability an event does not occur: $Y_i = 0$. The probability of: $(1 - P_i)$.

## 4. Results

In comparing the national soil test users to non-users (Table 2), soil testers have higher incomes in terms of gross margin (t=3.35, p=0.00) and gross output (t=2.98, p=0.00) per hectare, are younger (t=3.11, p=0.00), have larger farms (t=-2.64, p=0.00), larger dairy grazing platforms (t=-3.97, p=0.00), have larger dairy herds (t=-3.21, p=0.00), and apply higher quantities of nitrogen per hectare (t=2.34, p=0.02), but show no significant difference in concentrate and fertiliser (t=-1.37, p=0.17) expenditure, (t=-0.75, p=0.45), stocking density (t=-0.31, p=0.75), and direct costs (t=-1.51, p=0.13).

The insignificant t-tests for the expenditure variables[14] is noteworthy as cost saving is portrayed as a key characteristic of soil testing, yet there is no significant difference between the groups in relation to direct costs and fertiliser cost per hectare, this holds for full and the sub-sample. While it is expected that adopters benefit in terms of reduced cost on fertiliser, the strong positive relationship between intensity and expenditure on fertiliser (r=0.52) and quantity of nitrogen (0.57) used per hectare indicates more intensive farmers use greater quantities of chemical fertiliser. Interestingly, both groups, those who soil test and those who do not soil test, have an almost equivalent expenditure on fertiliser in both samples.

### Factors affecting the adoption of soil tests nationally

Results highlight agricultural policy as a key driver in the adoption of soil testing for the full sample (Table 3). Participation in either incentivised schemes (REPS) or complying with regulations such as the Nitrates Directive (derogation) increases the likelihood of soil testing on a regular basis. This is a positive finding for policy which aims to increase rates of adoption, with participants 12 times more likely to test regularly. However, based on national soil fertility data, this is accompanied by falling soil fertility rates, representing a disconnect between policy and practice implementation with a non-convergence around the desired optimum levels of soil fertility.

Having a larger dairy platform[15] also increases the likelihood of soil testing, for each additional increase in the size of the dairy platform there is a 3.8% increase in the likelihood of soil testing. A larger dairy platform may be more intensively grazed and therefore may require more demanding nutrient management. It is generally proximate to the holding and may traditionally receive more organic manure and, if so, may warrant more regular testing. Farmers who reseed are 2.5 times more likely to soil test regularly than those who do not while those who are discussion group members and conduct grass covers are 7.3 times more likely to soil test. The characteristics of the farm such as having a larger dairy platform is also associated with farm size and intensity. With more intensive farming there is also greater nutrient requirement from land and so it is not surprising the associated practices such as reseeding and performing grass covers are also significantly associated with regular soil testing.

In summary, national soil testers are more likely to (i) participate in REPS/Derogation (z=6.33, p=0.000), (ii) have larger dairy platforms (z=2.63, p=0.009), (iii) be a member of a discussion group and complete grass covers (z=-2.45, p=0.014) and (iv) have re-seeded in previous three years (z=2.19, p=0.029).

[14] The calculation of continuous variables is standardised on a per hectare basis.

[15] Hectaresof grazing allocated specifically for dairy cows.

 

### Factors affecting adoption by the voluntary sub-sample

As farmers have different motivations for soil testing, it is important to consider those soil testing in a voluntary capacity. Therefore, mandated users (REPS and derogation farms) are dropped from the analysis to examine voluntary behaviour. This reduces the sample to 86 participants, 39 users and 47 non-users, representing approximately 5500 holdings.

Voluntary soil test users (Table 4) have higher incomes in terms of gross margin (t=-2.52, p=0.01) and gross output (t=-2.73, p=0.00) per hectare than non-users. They also have larger farms (t=-2.87, p=0.01), and grazing platforms (t=-4.43, p=0.00), larger dairy herds (t=-3.68, p=0.00) and are, on average, younger (t=2.09, p=0.04).

The comparative descriptive statistics for the sub-sample (Table 4) are in line with full sample (Table 2) regarding the significantly larger expenditure on fertiliser and concentrates by soil testers than non-users, one exception is the number of days at grass: the soil test users in the voluntary group achieve significantly more days at grass than the non-users. This may be a reflection of their productive orientated grazing-intensive farming, also reflected in the logit analysis. In the voluntary logit model the policy REPS/Derogation farmers are dropped (Table 1), all other variables used in the national model are analysed. For the voluntary population results show (Table 5) farmers with formal agricultural education are more likely to soil test on a regular basis, as are the farmers who reseed and have larger dairy platforms.

In looking at the level of education attained by farmers, those farmers who have attended part-time courses are 7.6 times more likely to soil test than those who have no formal agricultural education. Farm size (measured by dairy platform) also has a positive and significant impact on the likelihood of soil testing. For each additional (hectare) increase in the size of the dairy grazing platform there is a 5.6% increase in the odds of testing. Farmers who have reseeded their farms are 3.6 times more likely to tests on a regular basis. This may reflect a broader nutrient management or productivity capacity of the farmers also reflected in the full sample of farmers.

In summary, voluntary soil testers are more likely to (i) have larger dairy platforms (z=2.71 p=0.007); (ii) have a formal agricultural education (z=2.52, p=0.012), and (iii) have re-seeded in the previous three years (z= 2.08, p=0.038).

## 5. Discussion

The t-tests highlight the economic and structural differences which exist between soil test users and non-users for the full sample and the voluntary sub-sample addressing the first research question of this study. The most notable results highlight that there is no significant difference between the average expenditure on fertiliser and concentrates for soil testers than non-testers. Higher fertilizer expenditure on more intensive farms is to be expected. Moreover, if implementing soil test results accurately at farm level there should also be convergence around optimal fertility trends, but we know that this is not the case over the past decade (Wall *et al.,* 2015). These findings highlight an anomaly, where the benefits of the widely adopted farm practice are not being realised by users. This raises questions concerning the on-farm implementation of soil test results. Furthermore users pose a greater threat to the environment with higher chemical nutrients utilised on their farms.

In exploring this further the second research question identifies those most likely to soil test on a regular basis for the sample and for the subsample. For the sample, results show larger farm size (dairy platform) reflecting intensity, farm practices (reseeding), farmers who are members of discussion groups and perform grass covers are more likely to soil test on a regular basis. The strongest factor influencing adoption for the full sample is policy (REPS/Derogation). This finding suggests that participation in schemes which mandate adoption (REPS/Derogation) does not perfectly predict soil testing on a regular basis. If participation in such schemes and regular practice use were perfectly correlated the variable would be automatically redundant in the model. From a policy perspective these findings are of interest given the importance of other farm practices such as reseeding and grass covers. The importance of soil for the sustainability of agriculture the development of a nutrient management capability may be an area farmers are interested in developing through further education.

Given the importance of policy in the national model, an analysis of a sub-sample of specialist dairy farmers focuses on farmers acting in a voluntary capacity. For the voluntary sub-sample formal agricultural education is a significant factor, soil testers are more likely to have participated in short part-time courses. This could be an indication of a farmers who select specific programmes or courses which fit with their farm needs. Reseeding and size of the dairy platform are also significant factors in identifying farmers likely to soil test regularly.

Seminal writers (Griliches, 1957; Mansfield, 1961) relate adoption to a single activity. However, more recent research views adoption as part of a social process (Rogers, 2003; Leeuwis, 2004). This paper not only identifies the characteristics of those adopting but also highlights the realities farmers are faced with in decision making, through identifying potential issues surrounding policy which mandates activity. This suggests there may be a need for research that moves beyond examining of rates of adoption and that takes a broader view of decision making, considering factors such as farmers' goals, objectives and perceptions towards using nutrient management practices and the willingness of farmers to develop a holistic approach in the development of a broader nutrient management capability. Ultimately implementation of practices and achieving the desired outcome should be the end policy goal. Policies to encourage uptake of new practices should consider end users motivations for adoption to ensure management tools aid the achievement of user goals (Pannell *et al.,* 2006).

The findings in this paper highlight that high rates of adoption associated with policy mandating practice use does not always result in the achievement of desired outcomes, in this case improved soil fertility. This paper suggests that the focus of future adoption studies should relate more closely to outcome measures. Policy should not only focus on increasing the rate of adoption or the time associated with spread and diffusion but should also incorporate, where possible, a focus on the benefits of using and implementing the farm practices in meeting farmer objectives. The findings from this study have identified policy as the key driver in adoption of soil testing but national trends indicate successful implementation is not being achieved.

Building on the findings of this research, five possible explanations for the anomaly between high rates of soil testing and low soil fertility levels in Ireland are suggested. These are as follows.

- Farmers test to fulfil mandatory obligations but may not use results.
- The introduction of increasingly stringent legislation regarding nutrient use is hindering farmers in reaching optimal agronomic production levels.
- Farmers do not wish to achieve optimal agronomic fertility levels.
- Multiple sources of information from the wider environment such as peers, personal experience, industry, media etc. may conflict and so hinder optimal decision making. For example inherent soil characteristics such as root development and water retention capacity (Karlen, Ditzler & Andrews 2003, Karlen & Stott 1994) are not captured by soil tests but may be an important consideration in decision making for farmers.
- Farmers only test poor quality soils and so the results show no apparent improvement over time.

There is a need for a greater understanding of the factors which motivate farmers to adopt practices in a volitional capacity rather than in incentivised fashion, as reward based systems are a powerful motivator of behaviour (Lawson & Samson 2001). This is important in an agricultural context given the existence of incentivised schemes which focus on increased rates of practice adoption. Where motivation to adopt is mandated by a policy instrument the longer term adoption in the absence of such policy may not occur. There is currently less emphasis on additional tailored supports which would aid farmers to achieve their 'soil based' objectives. Sufficient policy attention needs to be given to the outcomes and benefits of the practice in line with farmers objectives. For example, developing a mechanism to track successful changes and demonstrate benefits post adoption could encourage more long term commitment to practice use.

## 6. Conclusion

In the context of the anomaly between high rates of soil testing and low soil fertility levels in Ireland this paper presents the results of an analysis of the factors associated with soil testing in a nationally representative sample of 231 Irish dairy farmers, including an analysis a sub-sample of farmers who soil test in a voluntary capacity. The results suggest that policy is a key driver of soil testing behaviour in the full sample, as is participation in discussion group networks and conducting grass covers. Farm size and farm practices such as reseeding also increase the likelihood of regular soil testing for both the full sample and the voluntary sub-sample. Moreover, having formal education is a significant factor in increasing likelihood of soil testing amongst voluntary users. In both samples, there are no significant differences in fertiliser costs per hectare between soil test users and non-users. This suggests that soil test users are not reaping the efficiencies that might be expected. These findings raise questions regarding the impact of policy and regulation on practice implementation and the motivations surrounding the adoption of regular soil testing.

The results of this study suggest that there may be issues with the mandated adoption of farm management practices specifically for REPS and derogation farmers. There are a number of considerations for future agricultural policy approaches associated with this. One is the level of commitment to using the practice; is practice adoption based on fulfilment of programme requirements? A second consideration is establishing if the benefits of the technology correspond with the objectives of the farmer and reflect the productive capacity of the farm's resources. In a system where it is mandatory to adopt practices this is not considered. From a policy perspective, introducing a tailored response to needs may be more beneficial to the farmer and a focus on on-farm outcomes. Rewarding farmers who reduce their environmental pressure and risk to soil and water pollution, but also providing further extension to farmers who are currently farming on soils at less than optimal levels through tailoring and targeting farms is one approach which may be effective. Soil testing is a management intensive tool which requires the development of a skill: implementing the soil test results, and furthermore, the development of an overall farm nutrient management capability in making farm scale decisions. It is important to identify cohorts of adopters as a targeted approach can be taken to improve this capability through implementation supports and the use of outcome data in evaluating benefits of policy instruments. In agriculture the reliance on chemical fertiliser is not only of interest from a farm level economics perspective but also for the wider eco-system. The volatility of market prices for fertiliser does little to stabilise farm input cost and unpredictable weather conditions hinder nutrient management activities. It is for these reasons soil testing and its appropriate implementation is a key farm practice for sustainable agriculture.

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REFEREED ARTICLE

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# Sustainable Land Values and Price Premiums for North American Farmland

MARVIN J. PAINTER[1]

**ABSTRACT**

This paper analyses current farmland prices in five US states and five Canadian provinces to assess whether and to what extent there are current price premiums for ''irrational exuberance'' and non-farm influences such as urbanization, hobby farms, commercial development and other non-farm uses. It appears that the farmland market in North America is in a boom period, showing significant premiums for irrational exuberance. If interest rates continue to be low and commodity prices return to higher levels, these premiums could get even larger in the next few years. However, if inflation and interest rates rise while commodity prices remain lower, we may see a significant farmland price correction.

**KEYWORDS:** irrational exuberance; non-farm price premium; over/under valuation; valuation trend line

## 1. Introduction

In 2014, we saw significant price gains for stock markets and farmland in North America. The United States stock markets have averaged 4.5% total real return on investment since 1972 while US farmland has averaged 6.8% over the same period.[2] During that time period, stock markets and farmland have been over and under-valued relative to a growth value line, for varying degrees of magnitude and time. In Figure 1, the farmland over-valuation experienced in the 1975-1985 years is visible and it appears that an over-valuation may be occurring today, starting around 2010. On the Stock Market chart, the market was less volatile and somewhat stagnant from 1972 to the mid 90's, but then climbed significantly during the Dot-com craze, with a correction beginning in 2000 and carrying through the 2002 aftermath of 9-11. After 2002, stock markets were in a bull period until the 2008 financial crisis, which precipitated another large correction. After a fairly long recovery period, 2013 saw significant stock market gains and by the end of 2013, it appeared that a new plateau had been reached.

The phenomenon of over and under-valuation is very common in freely traded markets, especially in stock markets. True values are always being sought by many market participants but there is a tendency to over or under-shoot true value due to emotions such as greed and panic so corrections are necessary from time to time. Alan Greenspan, past chairman of the US Federal reserve, famously used the phrase ''irrational exuberance'' in a speech on December 5, 1996 at the beginning of the Dot-com bubble, to describe investor enthusiasm for buying and bidding up stock values, especially Dot-com stocks. This was largely interpreted at the time as a warning that the stock market may be overvalued. As can be seen in Figure 1, a large correction ensued three years later. At the end of 2013, it appeared that a stock market correction could be imminent as stock valuation multiples seemed to be at the top of the historical range, but prices did not seem to be hugely over-valued. However, by the end of 2013, US farmland prices had risen to very high levels, thought to be caused by high commodity prices and good yields, making farm cash flows very good. Also, high growth in profitability and low interest rates caused farmland valuation multiples to be higher than usual. The high cash flows combined with unusually high valuation multiples caused farmland prices to jump. It is possible that there is a certain amount of ''irrational exuberance'' built into the current farmland prices and, if so, a significant correction could occur if there is a drop in commodity prices or yields, if the sector starts to experience lower revenue and income growth, or if interest rates increase.

This paper analyses current farmland prices in five US states and five Canadian provinces to assess whether and to what extent there are current price premiums for ''irrational exuberance'' and non-farm influences such as urbanization, hobby farms, commercial development and other non-farm uses. The specific research questions are:

1. What is the current sustainable farmland value in each state and province compared to the actual observed prices;
2. For each state and province, estimate whether and to what extent there is a current price premium for ''irrational exuberance''; and

[2] US stock market returns are provided by Morgan Stanley International. US farmland returns are estimated in this study using USDA data (see methodology of this study for details).

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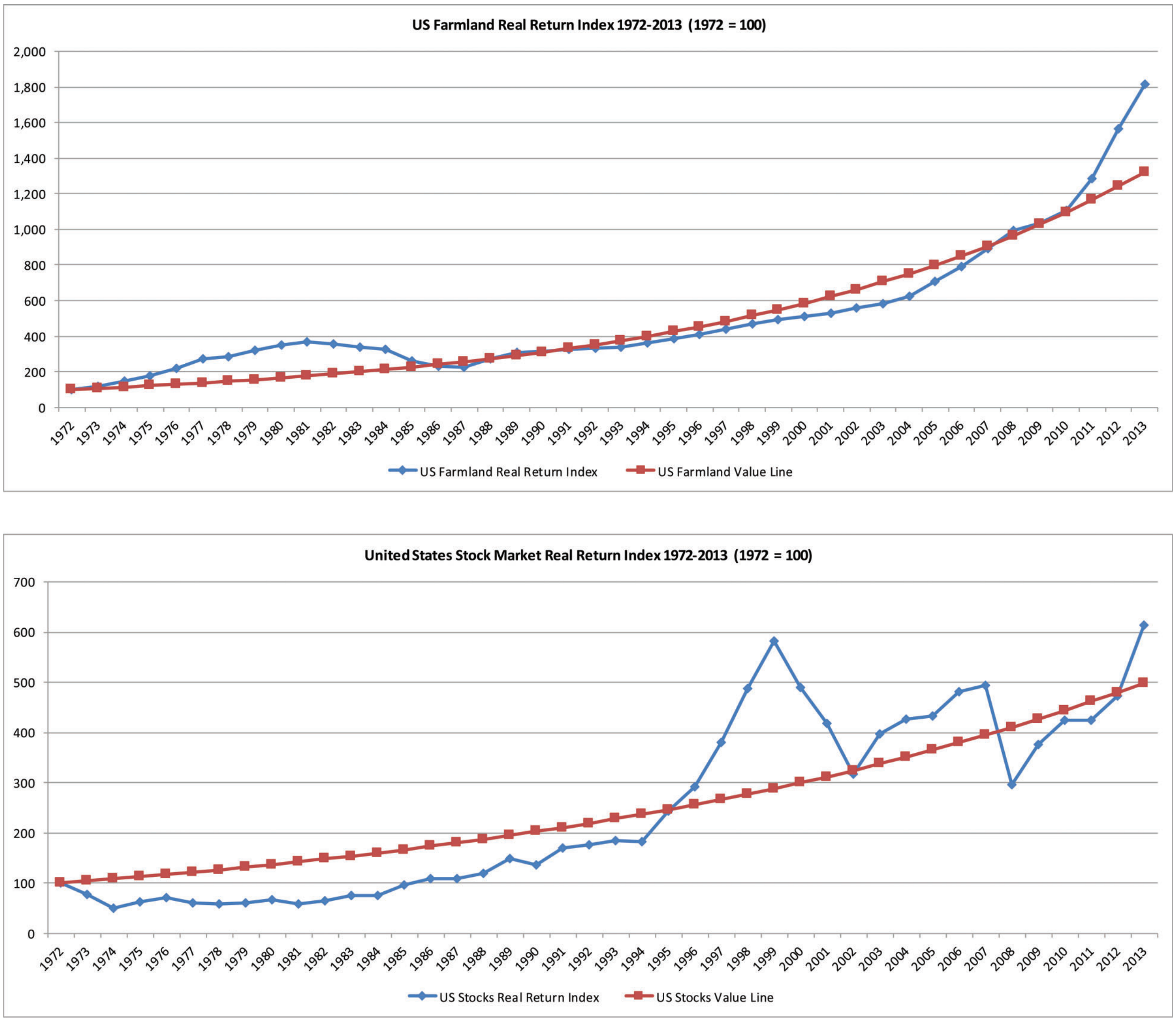


**Figure 1:** US stock market and farmland value growth 1972 – 2013

3. For each state and province, estimate whether and to what extent there is a current price premium for non-farm influences such as buying demand from non-farmers, where prices are not determined solely by farmland productivity.

The results illustrate and explain the price premiums for each state and province.

## 2. Past Research

Studies on farmland valuation by Melichar (1979) and Alston (1986) showed that farmland values could be explained using a discounted earning model. Melichar indicated the importance of estimating and including expected earnings growth as well as accounting for technological change so that a true estimate of earnings could be obtained. Alston concluded that growth in earnings, as opposed to other factors such as inflation, could explain capital gains on farmland, which supports the standard theory of valuation. Castle and Hoch (1982) indicated that valuation analysis must include expected growth in earnings and the discount rate used must not be the debt rate only but rather a risk-adjusted opportunity cost for farmland investors. Wiesensel, Schoney and Van Kooten (1988) suggested that previous years' land prices along with current farm rents explained 86% of farmland values, thereby supporting the discounted earning approach. Just and Miranowski (1993) suggested that inflation, changes in real returns on capital and farmland earnings were the major farmland value explanatory factors. Vasquez, Nelson and Hamilton (2002) found that farmland values in Idaho are largely determined by factors that affect profitability, as opposed to non-farm or urban pressures. Helmers, Shaik and Johnson (2005) found that the income capitalization approach including recent changes in land values provided a good predictor of farmland values. Painter (2008) assessed farmland values in Canada using a discounted cash flow model and found non-farm price influence in Ontario and Alberta. Overall, these past research studies suggest that farmland is valued similarly to other assets, such as stock market companies, by capitalizing future expected returns at current required rates of return.

 

## 3. Background And Methodology

### The discounted cash flow valuation model

To analyse and assess the current farmland price premiums in North America, a discounted cash flow model is employed:

$$V_0 = E_0 \frac{(1+g)}{r-g} \quad (1)$$

where:
$V_0$ = the current estimated value of farmland;
$E_0$ = the expected annuity of future sustainable earnings to farmland ownership in current dollars;
g = the expected average real growth in sustainable earnings to farmland equity. In a perfect market, g would also be equivalent to the expected capital gain yield on farmland, assuming there are no influences on farmland value other than farmland earnings;
r = the real required return on equity investment in farmland, where r is a combination of the real risk-free rate of return (t-bill real rate of return) and the risk premium required by equity investors in farmland.
and,
The farmland income multiple $(\frac{V_0}{E})$ is $IM = \frac{(1+g)}{r-g}$

Substituting IM into equation (1), $V_0 = E_0$ x IM. Note that the two factors affecting the income multiple are the expected growth in future income and the required return on investment, which is a function of interest rates and farmland investment risk.

### Estimating farmland yields

Farmland ownership yields are calculated annually for the 1972-2013 study period, for five Canadian provinces (Alberta, Saskatchewan, Manitoba, Ontario and Quebec) and five US states (Iowa, Illinois, Nebraska, Minnesota and Kansas).[3] In each province and state, aggregate farmland data is used to simulate a geographically diversified farmland holding. The total return to farmland ownership is divided into two parts; income return and capital gain return. The income return is based on the net lease revenue obtained from renting the farmland to farm operators. The capital gain return is the change from year to year in the market value of the land. A standard crop share approach is used where the landowner receives a percentage of the gross revenues produced. During this time period, rents were changing as North American farmers gradually adjusted to continuous cropping so for this study, the average crop share rent is 33% for 1972-80, 25% for 1980-90, and 17.5% from 1990 to 2013. The landowner is then responsible for paying property taxes and building depreciation to arrive at a net lease amount or income return. Hence, the annual income return per acre to farmland ownership is calculated as follows:

$$IR_t = LR_t - PT_t - BD_t \quad (2)$$

Where,
$IR_t$ = \$ income return to farmland per hectare in year t;

[3] Canadian data sources are Statistics Canada Cansim Tables 002-0001, 0003, 0005, 0009, 0012. US data source is the USDA website: http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx#27405

**Table 1:** Average nominal yields for Canadian and US farmland (1972 – 2013)

| Farmland Asset | Income (Dividend) Yield | Capital Gain Yield | Total Investment Yield |
|---|---|---|---|
| Canada: | | | |
| Alberta | 3.5% | 8.0% | 11.4% |
| Saskatchewan | 4.7% | 6.8% | 11.4% |
| Manitoba | 6.1% | 7.3% | 13.3% |
| Ontario | 3.7% | 8.0% | 11.7% |
| Quebec | 8.6% | 8.7% | 17.3% |
| Canadian Average | 5.3% | 7.8% | 13.0% |
| United States: | | | |
| Iowa | 4.5% | 7.4% | 11.8% |
| Illinois | 2.8% | 6.0% | 8.8% |
| Nebraska | 5.7% | 7.1% | 12.8% |
| Minnesota | 4.9% | 7.3% | 12.1% |
| Kansas | 5.5% | 5.8% | 11.3% |
| US Average | 4.7% | 6.7% | 11.4% |

$LR_t$ = gross lease (rent) revenue per hectare in year t;
$PT_t$ = property taxes per hectare in year t;
$BD_t$ = building depreciation per hectare in year t;

The annual income and capital gain yields for each province and state are calculated as follows:

$$IY_t = \frac{IR_t}{V_{t-1}} \quad (3)$$

Where;
$IY_t$ = % income yield per hectare in year t;
$IR_t$ = \$ income return to farmland per hectare in year t;
$V_{t-1}$ = average farmland value per hectare in year t-1.

$$CGY_t = \frac{V_t - V_{t-1}}{V_{t-1}} \quad (4)$$

Where;
$CGY_t$ = % capital gain yield per hectare in year t;
$V_t$, $V_{t-1}$ = average farmland values per hectare in years t and t-1, respectively.

Annual income and capital gain yields are calculated for each province and state, for the period 1972-2013. The annual total investment yields for each province and state are the sum of the annual income and capital gain yields, calculated as follows

$$ROI_t = \frac{IR_t}{V_{t-1}} + \frac{V_t - V_{t-1}}{V_{t-1}} \quad (5)$$

The resulting farmland ownership yields are provided in Table 1.

## 4. The Price/dividend Ratio For Farmland And Stock Markets

The farmland income return (IR) is akin to the dividend income (D) received by company stockholders and hence, the farmland price to income multiple is akin to the price

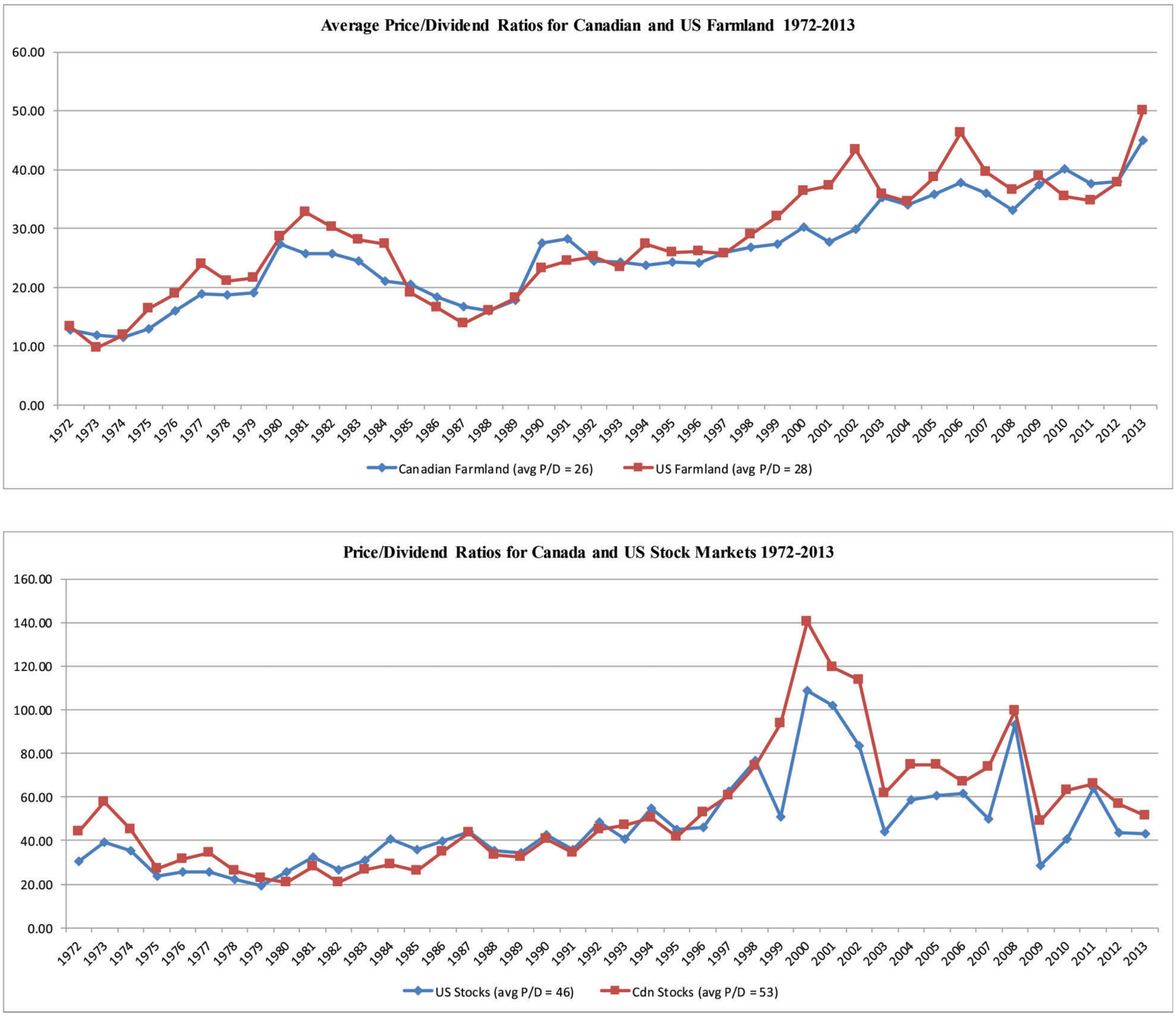


**Figure 2:** Price/dividend ratios for farmland and stock markets in Canada and US

to dividend (P/D) multiple in stock markets. Figure 2 compares actual P/D's for farmland and stock markets[4] for the period 1972-2013. For both farmland and stock markets the average P/D's are relatively stable, however, in both cases there are periods where the P/D's have risen above the normal (long-term average) range. Farmland price inflation in the 1975-1985 period can be explained by the increased income returns, as shown in Figure 3, as well as higher than average P/D's that investors used to value farmland. The increased farmland P/D at that time was likely a function of abnormally high income growth expectations, which is often a sign of ''irrational exuberance''. The Canadian and US stock market P/D's also show signs of ''irrational exuberance'' for the Dot-com bubble (1999-2000) and again in the run up to the 2008 financial crisis and correction. For 2013, the stock markets do not seem to be experiencing abnormally high P/D's but farmland P/D's are higher than their long-term averages, which may be contributing to a farmland price premium for ''irrational exuberance''.

## 5. Explaining The Non-farm Price Premium[5]

One of the difficulties in estimating farmland values is in isolating the impact of non-farm demand. Non-farm demand includes hobby farms, urban expansion, commercial development, and any other demands for farmland that are not for agricultural production. If non-farm demand in a province or state is significant, it will impact the provincial average farmland value, making the value greater than that supported by farmland earnings. The resulting non-farm price premium is not always supported by any measurable earnings from the land, making it difficult to assess. In the case of business and commercial use, there will be expected earnings from the commercial venture to assess but in the case of personal use, such as a hobby farm or personal residence, the buyers will not be looking for a cash flow from the land but expected future capital appreciation may be a significant factor in the purchase decision. The non-farm price premium can be explained using the discounted cash flow model, by breaking down the growth component, g,

[4] Stock market data for yields, prices and dividends is available at the Morgan Stanley website: http://www.mscibarra.com/legal/index_data_additional_terms_of_use.html?products/indices/international_equity_indices/gimi/stdindex/performance.html

[5] This section was also explained in Painter (2008).

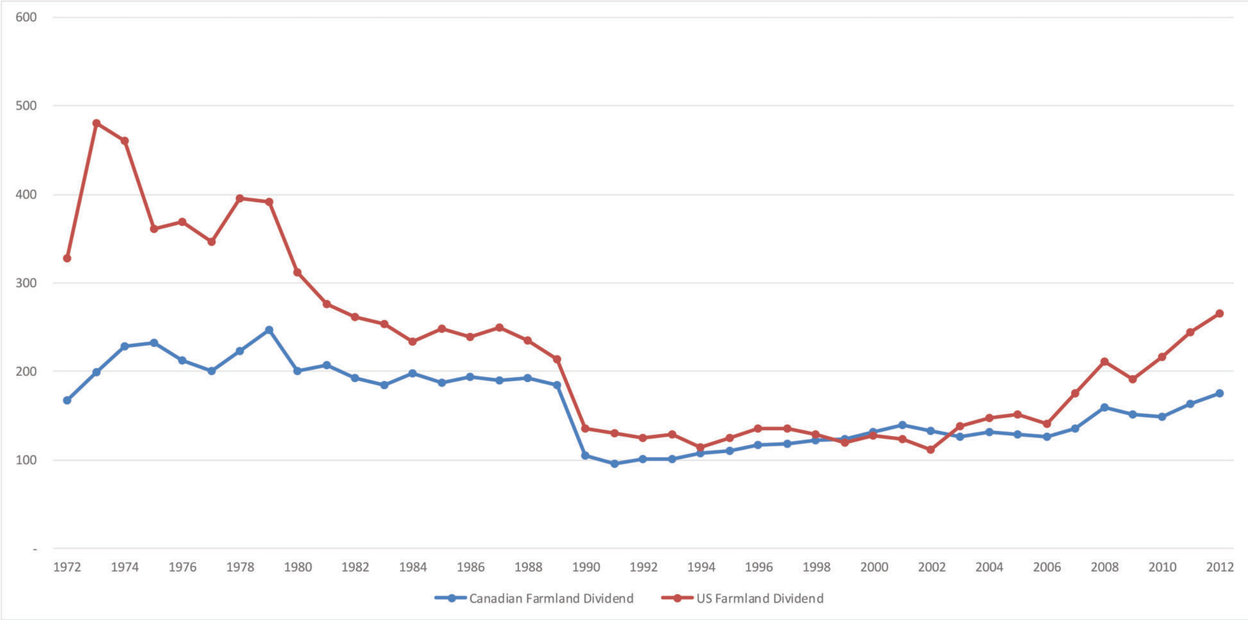


**Figure 3:** Average Canadian and US farmland dividends 1972-2013 (in real 2013 $/hectare)

into two parts; the expected growth in farmland value due to growth in the income return or farmland dividend (D) to owners, $g_f$, and the expected growth in the non-farm price premium due to non-farm demand, $g_{nf}$. To illustrate the breakdown of g, a numerical example is used for a farmer (as opposed to a non-farm or non-commercial buyer). Suppose $D_0$ is $300/hectare (net income return to the lessor), expected real growth is 1.5% and the required real return on investment is 5% annually. Applying equation (1) we get the estimate of value, as follows:

$$V_0 = D_0 \frac{(1+g)}{r-g} = (300)\text{x}(1.015)/(.05 - .015)$$
$$= \$300 \text{ times P/D of } 29 \; = \; \$8,700$$

Equation (1) can be re-written as:

$$r = \frac{D_0(1+g)}{V} + g = \text{Income Yield} + \text{Capital Gain Yield}$$

Applying to the example:

$$r = \frac{300(1.015)}{8700} + .015 = 3.5\%(\text{income yield})$$
$$+ 1.5\% \text{ (CG yield)} = 5\% \text{ total yield}$$

Therefore, if the farmer paid $8,700/hectare and actually received $300/hectare income, growing at 1.5% per year, he would earn the required rate of return of 5% annually (3.5% as income yield and 1.5% from appreciating land value). $8,700/hectare is referred to as the sustainable farmland value where the expected future earnings support that value. But what if the asking price for the same farmland is $10,000/hectare? From an agricultural point of view, the asking price is too high, as indicated by the expected return on investment, r, if $10,000 is paid:

$$r = \frac{300(1.015)}{10,000} + .015 = 3.05\% \text{ (income yield)}$$
$$+ 1.5\% \text{ (CG yield)} = 4.55\% \text{ total yield}$$

The expected return on investment is too low, which should cause the market to lower the selling price to $8,700. However, if the buyer expected there would be further growth in value due to non-farm demand for the land, he may be willing to pay the $10,000 asking price. The total asking price of $10,000 can be divided into a sustainable farm price of $8,700 and a non-farm premium of $1,300. If the farm price of $8,700 can earn a return of 5% (income yield of 3.5% plus CG yield of 1.5%) then for a total yield of 5% on the asking price of $10,000, the non-farm premium of $1,300 has to appreciate by 5% per year (it also has to earn 5%). Therefore, if the buyer expected farmland earnings growth, $g_f$ = 1.5% and additionally, growth in the non-farm price premium, $g_{nf}$ = 5%, then the total farmland value would be $10,000. Therefore, a non-farm price premium can persist as long as there is persistent non-farm demand and growth in non-farm value.

## 6. Methodology For Estimating Farmland Price Premiums

The objective of this paper is to determine whether and to what extent there are current price premiums associated with North American farmland values. The analysis involves the following steps:

Step 1: Sustainable current farmland values are estimated for each province and state using past 5-year averages as estimates for future income returns in each province and state, past 20-year average real growth and risk premiums averaged over all provinces and states, and an expected future real risk free rate of 1.0%. This produces sustainable farmland P/D's of 29.2 and 30.7 (calculations are shown in the results section), for Canadian and US farmland, respectively which are then used are used to determine sustainable current farmland values.

Step 2: Optimistic farmland values are estimated using aggressive estimates of future income returns, growth and risk premiums, as happened in the 1975-1985 farmland

**Table 2:** Estimated North American farmland price premiums using historical income, growth and risk premium data for the period 1972 - 2013

| **Canada:** | **Alberta** | **Saskatchewan** | **Manitoba** | **Ontario** | **Quebec** |
|---|---|---|---|---|---|
| **Farmland Dividends (net lease revenue/hectare): real 2013 $/hectare** | | | | | |
| Sustainable (past 5yr avg) | 73.14 | 63.80 | 102.00 | 270.17 | 304.18 |
| Optimistic (2013 div) | 80.94 | 72.16 | 113.08 | 289.13 | 310.85 |
| **Farmland Dividend Growth: average real growth** | | | | | |
| Sustainable (20 year average) | 2.49% | 2.49% | 2.49% | 2.49% | 2.49% |
| Optimistic (Sust + .5%) | 2.99% | 2.99% | 2.99% | 2.99% | 2.99% |
| **Farmland Risk Premium** | | | | | |
| 30 yr average | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
| **Real Risk-Free Rate of Interest** | | | | | |
| Sustainable | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |
| Optimistic | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| **Estimated Price/Dividend Ratios (P/D's)** | | | | | |
| Sustainable | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 |
| Optimistic | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 |
| **Estimated Canadian Farmland Values ($/hectare)** | | | | | |
| Sustainable | 2,136 | 1,863 | 2,978 | 7,889 | 8,882 |
| Optimistic | 3,321 | 2,961 | 4,640 | 11,864 | 12,755 |
| Actual 2013 | 4,777 | 2,176 | 3,428 | 20,790 | 10,451 |
| **IE price Premium** | 1,185 | 313 | 450 | 3,975 | 1,569 |
| **Non-Farm Price Premium** | 1,456 | 0 | 0 | 8,926 | 0 |
| **United States:** | **Iowa** | **Illinois** | **Nebraska** | **Minnesota** | **Kansas** |
| **Farmland Dividends (net lease revenue/hectare): real 2013 $/hectare** | | | | | |
| Sustainable (past 5yr avg) | 344.12 | 235.03 | 157.63 | 257.34 | 118.17 |
| Optimistic (2013 div) | 367.22 | 209.82 | 162.31 | 299.74 | 116.78 |
| **Farmland Dividend Growth: average real growth** | | | | | |
| Sustainable (20 year average) | 2.56% | 2.56% | 2.56% | 2.56% | 2.56% |
| Optimistic (Sust + .5%) | 3.06% | 3.06% | 3.06% | 3.06% | 3.06% |
| **Farmland Risk Premium** | | | | | |
| 30 yr average | 4.9% | 4.9% | 4.9% | 4.9% | 4.9% |
| **Real Risk-Free Rate of Interest** | | | | | |
| Sustainable | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |
| Optimistic | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| **Estimated Price/Dividend Ratios (P/D's)** | | | | | |
| Sustainable | 30.7 | 30.7 | 30.7 | 30.7 | 30.7 |
| Optimistic | 44.0 | 44.0 | 44.0 | 44.0 | 44.0 |
| **Estimated US Farmland Values ($/hectare)** | | | | | |
| Sustainable | 10,567 | 7,217 | 4,840 | 7,902 | 3,629 |
| Optimistic | 16,173 | 9,241 | 7,149 | 13,201 | 5,143 |
| Actual 2013 | 19,019 | 17,537 | 6,916 | 10,621 | 4,323 |
| **IE price Premium** | 5,607 | 2,024 | 2,076 | 2,719 | 694 |
| **Non-Farm Price Premium** | 2,846 | 8,296 | 0 | 0 | 0 |

price bubble. The farmland income return for 2013 is used as the expected future return, which for both countries is significantly higher than the past 5-year average return used for the sustainable value. An optimistic growth rate of 0.5% higher than the sustainable level in step 1 and a required rate of return of 0.5% lower than in the sustainable level in step 1 (lower risk premium) would produce optimistic farmland P/D's of 41.0 and 44.0, for Canadian and US farmland, respectively. The optimistic P/D's are applied to 2013 farmland income returns to create optimistic farmland value estimates.

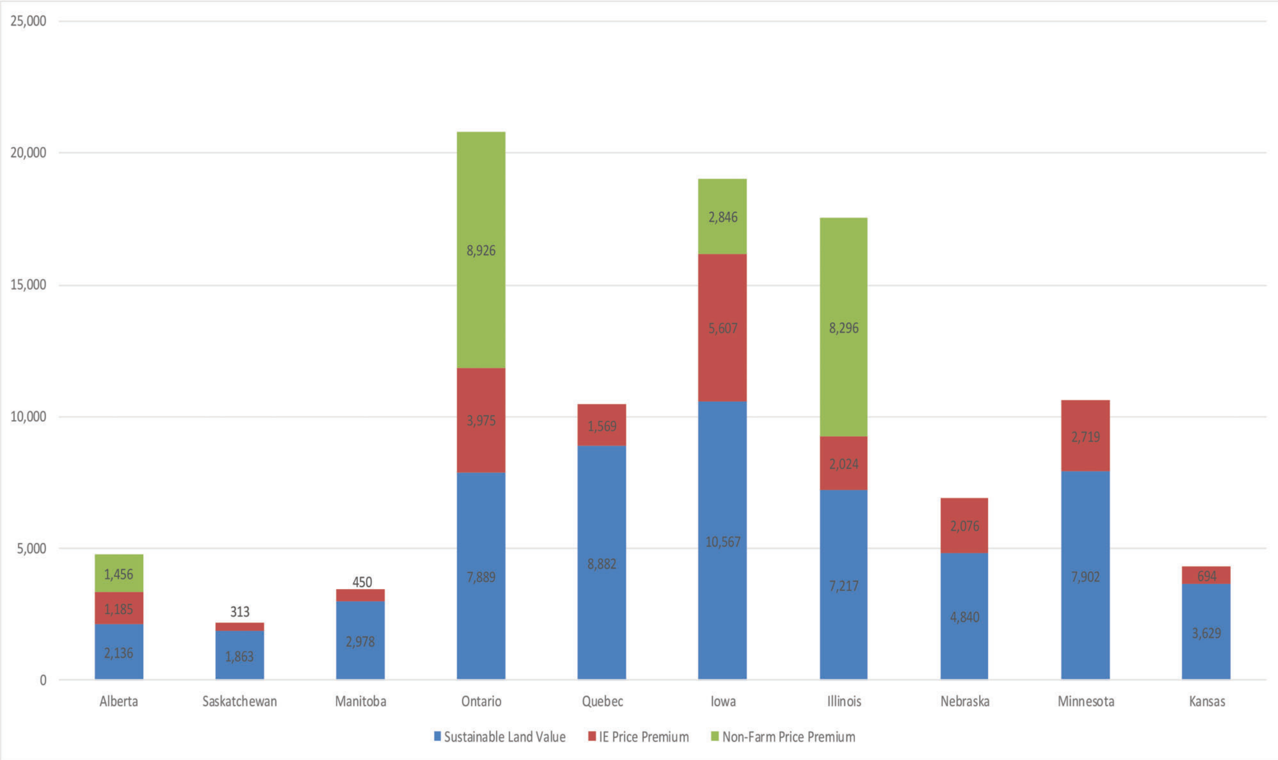


**Figure 4:** Sustainable land values and price premiums for North American farmland ($/hectare)

Step 3: Actual farmland prices for 2013 are compared to the sustainable and optimistic estimates. If the actual price is close to the sustainable estimate, the land is considered to be fairly valued with no price premiums. If the actual land price is greater than the sustainable estimate, especially if it is as high as the optimistic value, there is considered to be a farmland price premium for ''irrational exuberance''. To the extent that the current farmland price is greater than the optimistic estimate, there is also considered to be a non-farm price premium. The next section illustrates the extent to which there are price premiums for farmland in each of the Canadian provinces and US states.

## 7. Results: Assessing The Current Farmland Price Premiums

Table 2 provides the data analysis and results associated with calculating farmland price premiums and Figure 4 illustrates the results. Every province and state included in this study exhibits a price premium for ''irrational exuberance'' (IE), although some more than others, implying that North American farmland is overpriced. But by how much? The IE premium could be considered an indicator of the amount that the farmland is currently overvalued. For example, in Saskatchewan and Illinois, the IE premiums represents 14% of the 2013 stated value, while in Alberta it is 25% and Iowa is 29%, representing significant overvaluation. The implication is that if net lease revenues (dividends) fall back to average levels, interest rates and/or risk premiums rise to average levels (or at least do not decline), and growth in net lease revenues falls back to average levels, then the IE premiums will disappear and land prices will correct.

The data for this study included up to the year 2013. What has happened since the end of 2013? In Canada, farmland prices have continued to rise, with 2015 prices 23% higher than 2013, on average for the five provinces in this study. In May 2014, Michael Hoffort at Farm Credit Canada stated; ''As of right now we're quite comfortable that the economics still work with what we're seeing in farmland prices,'' but he also cautioned that some forecasts suggest farmland prices will soften (http://www.cbc.ca/news/canada/saskatchewan/eye-popping-farmland-prices-may-have-peaked-experts-say-1.2629259). The president of Toronto-based Bonnefield, Tom Eisenhaur, said farmland has been one of the most lucrative and secure investments especially when markets are volatile, and ''a better hedge against inflation than gold.'' Eisenhaur said he expects the price of land to continue to rise, if not at the same rate as over the past decade. (http://www.cbc.ca/news/canada/soaring-farmland-prices-a-crisis-in-the-making-don-pittis-1.2420223).

In the United States, U.S. policymakers and bankers feared a significant decline in farmland prices for 2014, but instead, they were up 8 percent as of August 1 according to the U.S. Department of Agriculture (USDA). They expect values - especially for prime farmland - to hold near record highs even though corn and soybeans are at four-year lows. The reason? Farming families have money from recent boom years to invest into assets they think give long-term value. (http://www.reuters.com/article/2014/09/07/usa-farmland-values-idUSL3N0R565R20140907). US Farmland prices in 2015 for the five states in this study, were up an average of 9% over 2013 prices.

It appears that the farmland market in North America is in a boom period. If interest rates continue to be low and commodity prices return to higher levels, these premiums could get even larger in the next few years.

However, if inflation and interest rates rise while commodity prices trend lower, we may see a significant farmland price correction.

## About the author

**Marvin J. Painter** teaches entrepreneurship and has been involved in consulting projects that include business plans, feasibility studies for agribusiness ventures and farmland and business valuations both for forensic and investment purposes.

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# REFEREED ARTICLE

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# Farmer livelihood assets contributing to the sustainable livelihoods of smallholder livestock farmers in the Northeast Region of Thailand

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**ABSTRACT**

This study assesses the livelihood sustainability of smallholder livestock farmers in the Northeast Region of Thailand. Three livestock farming systems, ruminant (RM), non-ruminant (NRM), and mixed livestock farming (MF) were analysed. A total of 205 households were sampled in a district that focuses on livestock farming. Linear discriminant analysis was used to identify significant contributing factors to sustainability. For RM and MF, the income-expenditure ratio was identified as a significant factor, and for NRM the significant factor is adequate experience with livestock rearing. The results suggest that livestock farming is a good livelihood option for smallholders. Human assets are vital and need to be improved through training supported by appropriate information systems for livelihood improvement. The concerned agencies, particularly government and local organizations, could be more proactively involved in terms of policy planning, project formulation, and implementation.

**KEYWORDS:** Livestock farming system; livelihood assets; smallholder livestock farmers; sustainable livelihood; rural development; Thailand

## 1. Introduction

Agriculture remains an important sector of the economy in Thailand and supports 25% of the population. The major aspects of agricultural production are linked with a variety of crop cultivation systems, horticulture, livestock and fisheries. Over the last two decades, the GDP contribution of agriculture has been between 8 to 10%, according to the Ministry of Agriculture and Cooperatives (MOAC, 2011). Among households dependent on this sector, about 2 million are below the poverty line, with an annual average income less than THB[3] 18,000 per person (MOAC, 2011). The challenge lies in bringing agricultural households out of poverty and making them sustainable.

Thailand has been emphasizing the sustainability concept to improve farmers' livelihoods since the 1990s (Chanpen, 1995; Jitsanguan, 2000; Jitsanguan, 2001). Towards this end, various methods of livestock production have been integrated into agricultural systems (Ito and Matsumoto, 2002; FAO, 2002), and many studies have confirmed that livestock can bring high economic returns (Dovie *et al.*, 2004), and improve socio-economic status, and reduce poverty among smallholder farmers (LCDI[4], 2004; De Haan, 2005; Dixon *et al.*, 2001; ILRI[5], 2003; ILRI, 2011; Holmann *et al.*, 2005).

The gap between farmers and those engaged in other occupations is wide, and farmers are considered the poorest group (FAO, 2001). A review of agricultural GDP and agricultural development policies in Thailand during the last two decades reveals that agricultural development projects often focus on assessing achievements only in terms of increased farm and livestock production and income, rather than addressing the achievement of sustainable livelihoods using available assets.

Since the early 1990s, sustainable livelihoods has been addressed by many as an important component of sustainable development. Most of the discussion on sustainable livelihoods has focused on rural areas, where people make a living from some kind of primary self-managed production system (Krantz, 2001). Many rural people diversify household income sources, which is an effective strategy for coping with adversity and improving overall security (Worku, 2007). According to Chambers and

[3] THB: Thai Baht; 1 USD equals approximately 35 THB as at 30 October 2016.

[4] Local Community Development Institution.

[5] International Livestock Research Institute.

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Conway (1991, p.6), "A livelihood is sustainable if it can cope with and recover from stress and shocks, maintain or enhance capabilities and assets, and provide sustainable livelihood opportunities for the next generation in the short- and long-term", to which Scoones (1998, p.5) adds, "…while not undermining the natural resource base."

Livelihoods are comprised of people, their capabilities, and their means of making a living, and include both tangible resources and intangible assets. Livelihood activities, assets (natural, physical, human, financial and social) and access to assets are what determine the standard of living attained by individuals and households (Ellis, 1999). The sustainable livelihood approach (SLA) puts people at the centre of a development process or intervention, and is based on the belief that people need a range of assets to achieve positive livelihood outcomes and sustain positive changes (Carney, 1999; DFID, 1999; DFID, 1998; Brocklesby and Fisher, 2003).

The Department for International Development (DFID) has adopted SLA as a standard tool to improve understanding of livelihoods by identifying the main factors that affect them, and the relationships that can be used in planning new and evaluating existing development activities (Adato and Meinzen-Dick, 2002; DFID, 1999). SLA helps us to understand farmers' livelihood assets, strategies, and outcomes, which can be used to analyse livelihood sustainability.

The objective of this paper is to assess the livelihood assets of smallholder livestock farmers by looking at their human, natural, physical, social, and financial assets, and to use asset variables to explain sustainability. SLA is used as a framework to select livelihood asset variables in three systems, i) ruminant livestock farming or RM (e.g. cattle and buffalo); ii) non-ruminant livestock farming or NRM (e.g. swine and poultry), and iii) mixed livestock farming or MF (a mix of ruminant and non-ruminant animals). Farmers were classified as smallholder farmers if their land holding size was less than 22 rai (3.52 ha), and linear discriminant function analysis was used to identify significant factors.

## 2. Material And Methods

### Study area

Non Sung District was selected as the study area because it is an important district for livestock farming in Thailand. Non Sung is located in the central part of Nakhon Ratchasima Province in the Northeast Region (Figure 1). Nakhon Ratchasima Meteorological Station reported that from 2000 to 2014, the average number of rainy days was 102 per year, with average annual rainfall of 1,050 mm, which is 65% of the national average. Seasonal hazards are drought and high saline soil (January-April), occasional flooding (June-October), plant pests (dry season), and animal diseases (rainy season). These characteristics of Non Sung District present common features of the Northeast Region, which is characterized by a poor natural resource base. The district consists of 16 sub-districts and 208 villages. Eighty-six percent of the population is engaged in agriculture. Due to animal disease outbreaks, the number of households rearing livestock declined from 11,635 households in 2005 to 6,692 households in 2009. Since then, the number of livestock farmers has been gradually increasing. According to Thailand's Department of Livestock Development (DLD), in 2014, some 7,358 farm households were engaged in livestock farming (DLD, 2014).

### Data and methods

This is an exploratory and analytical research using both quantitative and qualitative data, collected from secondary and primary sources. The primary data was collected in a reconnaissance survey and key informant interviews to profile area characteristics, common problems, and smallholder livestock farming systems. Group discussions were conducted to identify and select variables followed by a household survey with a structured questionnaire to collect data from sample households. A sample size of 205 households was drawn. A stratified, simple random sampling method was used to draw samples proportionately from all sub-districts in Non Sung. The number of farmers in RM, NRM, and MF systems was 88, 52, and 65, respectively. Socio-economic characteristics and the livelihood asset structure of farmers in the three systems are compared using pentagon graphs. Linear discriminant analysis was applied to identify linear functions to classify farmers into 'non-improved' or 'improved' livelihood groups as an indicator of sustainable livelihoods linked with livestock farming.

Farmers were asked to evaluate the impact of livestock farming in terms of 'better' status (improved living) or 'poorer' status (non-improved living), before and after engaging in livestock farming. If farmers feel they have improved their living standards, it is reasonable to assume they will be able to sustain their livestock farming operations. A 'successful' livelihood can be predicted by placing one or more of the independent variables into the discriminant functions. A case can be predicted to fall in the 'improved living' group when the value of function (D) is higher than zero, and into the 'non-improved living' group when the value of (D) is lower than zero. The self-reported status of a farmer's livelihood was taken as the dependent variable. Equation (1) is the discriminant model applied in this study.

$$D = D_2 - D_1$$

$$= (a_2 + b_{21}X_1 + b_{22}X_2 + \ldots + b_{2n}X_n) - (a_1 + b_{11}X_1 + b_{12}X_2 + \ldots + b_{1n}X_n)$$

$$= (a_2 - a_1) + (b_{21} - b_{11})X_1 + (b_{22} - b_{12}) X_2 + \ldots + (b_{2n} - b_{1n})X_n \quad (1)$$

Where,

D = Discriminant function

$D_1$ = Classification function of group 1: non-improved living group

$D_2$ = Classification function of group 2: improved living group

$a_j$ = Constant score

b = Non-standardized coefficients

X = Independent variable or discriminant variable

n = the number of discriminant variables where $n \geqslant 1$

A livelihood asset index was developed using a Likert scale by computing a weighted average index (WAI) for

 

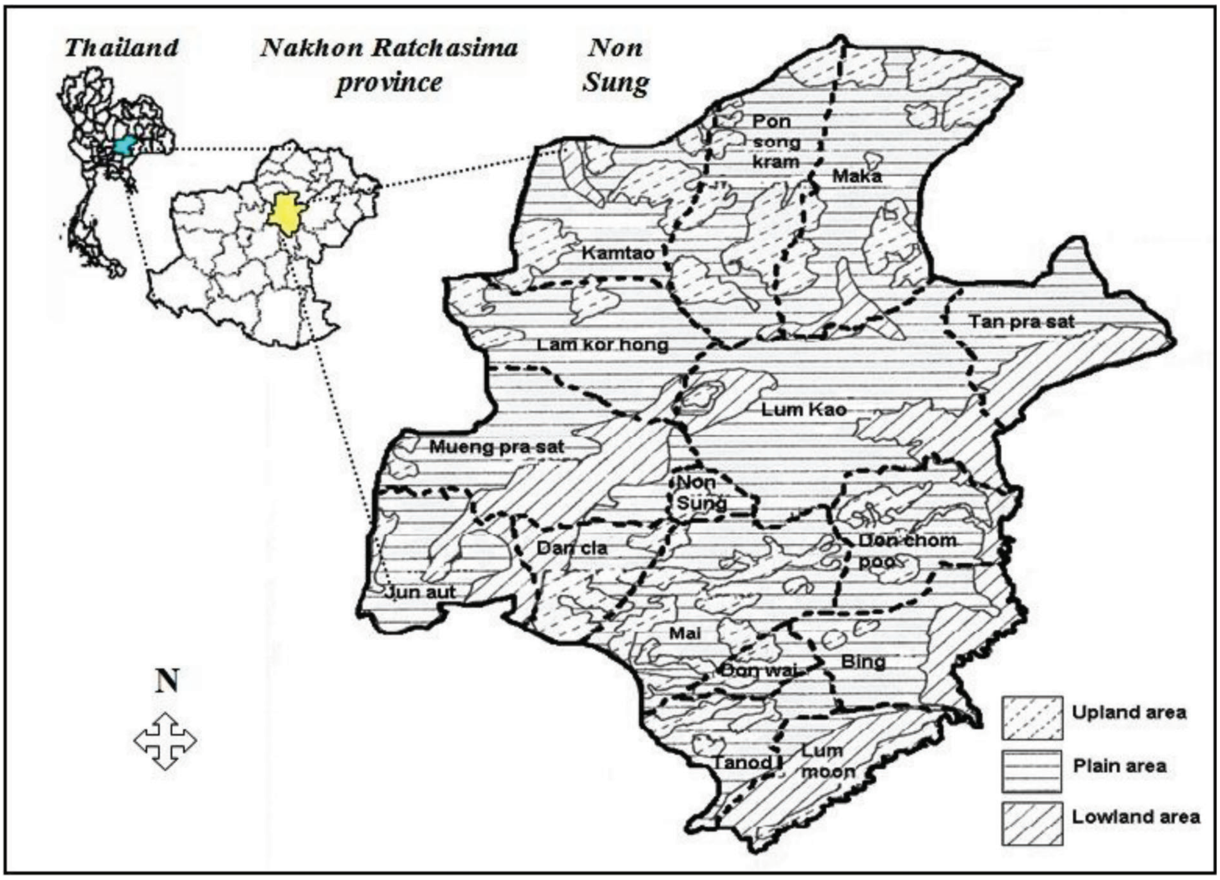


**Figure 1:** Map of Non Sung District, Nakhon Ratchasima Province

**Table 1:** Ratings of weighted average indices

| WAI Score | 0.00-0.20 | 0.21-0.40 | 0.41-0.60 | 0.61-0.80 | 0.81-1.00 |
|---|---|---|---|---|---|
| Adequacy | High Inadequacy | Inadequacy | Moderate | Adequacy | High Adequacy |
| Accessibility | Never | Rarely | Sometime | Often | Always |
| Quality, Security | Very Poor | Poor | Moderate | Good | Very Good |
| Ability Level | Very Low | Low | Moderate | High | Very High |
| **Livelihood Asset Index** | **Very Low** | **Low** | **Moderate** | **High** | **Very High** |

each category of asset for the three systems. A five-point Likert scale was used (from 0 to 1) with variable weights for five classes (0.2, 0.4, 0.6, 0.8, and 1.0). Weight 0.2 is the lowest, or 'least situation' and 1 is the highest or 'best situation'.

The WAI is defined in Equation (2):

$$WAI = (W_1F_1 + W_1F_2 + W_3F_3 + W_4F_4 + W_5F_5)/N \quad (2)$$

Where, $W_1$ = 0.2, $W_2$ = 0.4, $W_3$ = 0.6, $W_4$ = 0.8, and $W_5$ = 1.0; and $F_1$ to $F_n$ (where n = 5) are the respective frequencies of response under those classes, and N is total responses.

The WAI values are presented in Table 1.

## 3. Results And Discussion

### Livelihood asset analysis

The socio-economic profile and livelihood structure of smallholder livestock farmers is presented in Table 2. Five livelihood assets under three systems were analysed and compared using a set of indicators for each asset. The indicators under Human Asset are: adequacy of labourers, experience and skill, educational attainment of the labourers, accessibility to training, accessibility to information, and health status of the farmer.

Natural Assets include: adequacy of land, quality of soil, adequacy of water, and quality of water.

Physical Capital indicators are: accessibility to infrastructure services, adequacy of services, quality of services, adequacy of animal shelters, sanitation of animal shelters, security of animal shelters against theft, and adequacy of machines and instruments.

Social Assets has three indicators: social participation, community security, and market accessibility.

Financial Assets similarly has three indicators: adequacy of savings, accessibility to credit sources, and loan repayment ability of the farmer.

***Human assets*** refer to the status of individuals and farm household members in terms of labourers, skill, knowledge, and health status.

In Thailand, farm labour availability is declining due to an occupational shift to non-agricultural activities. Farmers using RM and MF systems have relatively more inadequate labour than farmers using NRM systems.

**Table 2:** Socio-economic profile and livelihood structure of smallholder livestock farmers

| Socio-economic profile and livelihood structure | | livestock farming system | | |
|---|---|---|---|---|
| | | RM | NRM | MF |
| Number of households | Households | 88 | 52 | 65 |
| Average household size | Persons/HH | 4.38 | 3.98 | 4.45 |
| Average labourers for livestock farming | Persons/HH | 1.95 | 1.92 | 2.00 |
| Age of labourer | | | | |
| Minimum-maximum age of labourer | Years | 13-80 | 22-81 | 14-84 |
| Average age of labourers | Years | 51 | 53 | 50 |
| Labourers older than 50 years | % | 50.00 | 55.00 | 48.46 |
| Educational level of labourers Primary level | % | 83.98 | 84.00 | 84.38 |
| Higher level | % | 14.53 | 13.00 | 13.08 |
| Farmers in very good health | % | 88.64 | 90.38 | 84.62 |
| Adequate labourers for livestock farming | % | 22.72 | 36.54 | 21.54 |
| Adequate experience and skill for livestock farming | % | 31.82 | 25.00 | 21.54 |
| Farmers with access to training about livestock | % | 21.59 | 17.31 | 9.24 |
| Farmers with access to information about livestock | % | 36.37 | 36.54 | 30.77 |
| Land holding size | (1ha=6.25rai) | | | |
| Average land holding size | Rai/HH | 21.32 | 15.94 | 16.60 |
| Average owned land size with title deed | Rai/HH | 10.83 | 8.22 | 10.79 |
| Insufficient land for livestock farming | % | 32.95 | 25.00 | 49.23 |
| Insufficient water for livestock farming | % | 26.55 | 11.54 | 43.07 |
| Average farm size | | | | |
| Cattle and buffalo | Heads/HH | 11 | - | 10 |
| Swine | Heads/HH | - | 21 | 10 |
| Chickens | Heads/HH | - | 36 | 27 |
| Ducks | Heads/HH | - | 29 | 29 |
| Infrastructure system | | | | |
| High accessibility | % | 94.31 | 90.39 | 86.15 |
| Adequate infrastructure facilities | % | 88.63 | 84.61 | 76.93 |
| Livestock housing | | | | |
| High safety and security | % | 48.86 | 40.38 | 41.54 |
| Moderate sanitation | % | 57.95 | 63.46 | 56.92 |
| Highly adequate livestock housing | % | 45.46 | 44.23 | 35.38 |
| High adequacy machinery and instruments | % | 60.23 | 48.07 | 49.23 |
| Participate in social group s& activities | % | 47.73 | 51.92 | 53.95 |
| High security in social | % | 89.77 | 61.54 | 69.23 |
| High accessibility to markets | % | 36.36 | 44.23 | 40.00 |
| Return from livestock farming | | | | |
| Average income from livestock | '000 Baht/HH | 86.59 | 158.28 | 125.87 |
| Average profit | '000 Baht/HH | 19.43 | 37.63 | 19.81 |
| Farmers who have savings | % | 97.73 | 82.69 | 92.31 |
| Farmers indebted | % | 77.27 | 78.85 | 75.38 |
| Average short-term debt (< 1 year) | '000 Baht/Debtor | 32 | 35 | 28 |
| Average medium-term debt (2-5 years) | '000 Baht/Debtor | 47 | 138 | 35 |
| Average long-term debt (>5 years) | '000 Baht/Debtor | 214 | 113 | 89 |
| High accessibility to credit | % | 44.32 | 51.92 | 36.92 |
| High repayment ability | % | 46.59 | 48.08 | 43.08 |

People involved in livestock rearing activities are mainly 50-60 years of age however, the research found an interesting fact that this occupation can employ a wide range of rural labours such as teenagers and over 80 years old, as long as they are in good health. More than 80% of farmers in all systems report being in good health.

Most farmers have only primary level education. The low education level is a constraint on farmers' improvement. Farmers in RM systems have more experience with livestock farming than those in NRM and MF systems. However, most farmers in all systems follow traditional practices for ruminant rearing and would benefit from improving their knowledge. For example, farmers in RM systems lack knowledge of marketing, farmers in NRM lack knowledge about vaccinations, DLD livestock farm standards, and commercial farming systems. Farmers in MF systems lack knowledge about breeding and crossbreed selection. Only 20% of farmers have trained or received information on livestock farming. Most are dissatisfied with the knowledge they gained through training. Government agencies, the private sector, and suppliers are important sources of information. Middlemen mostly provide market and price information. Informal meetings among farmers are a common way of sharing information.

***Natural assets*** are basic resources such as land, soil, water, and animals needed to generate food and income. Half the farmers in MF and 30% in other systems have insufficient land for effective livestock rearing. The average land holding size of farmers in RM, NRM, and MF system is 21.32, 15.94, and 16.60 rai, respectively (1ha = 6.25 rai). Insufficient land and poor soil fertility are among farmers' major concerns. The average land owned by farmers is about half their total land holdings (10.83, 8.22, and 10.79 rai, for RM, NRM and MF respectively). Households with larger land holdings tend to invest, and wealthier households are more likely to invest larger amounts (Hohfeld and Waibel, 2013).

 

Land ownership reduces risk and provides incentives for long-term investment. A land title deed also strengthens farmers' rights and livelihood security, for example, a title deed can be used as collateral for loans.

Most farmers have soil problems that require help from government agencies for soil quality improvement. Few MF farmers employ good management practices such as allocating high land for dwellings and ruminant sheds, sloping areas for non-ruminant sheds, and low lying land for cultivation and water storage. They also need land for grazing and fodder production.

The common water sources in Non Sung are small open water channels, groundwater, village water supplies, and locally created small irrigation systems. Quality of water is 'moderate' as assessed by farmers. During the dry season, there are water shortages, high salinity, and water contamination problems. Nearly half the farmers in MF systems have inadequate water for livestock farming and most need to increase the water storage capacity of ponds and seek other sources for livestock production.

Livestock is a natural asset by itself, and animal draught power is considered a physical asset (DFID, 1999). Livestock can also be considered a social asset if they are kept as a mark of social status (Stroebel *et al.*, 2011). Native beef cattle are favoured because of their high disease resistance and suitability to the less than optimal natural conditions of the Northeast. Dairy cattle are not popular due to generally saline water and the lack of milk collection centres. The role of ruminant animals, especially buffalo, for draught power has likewise declined with increased farm mechanization. The average number of cattle and buffalo in RM and MF system has declined to 10 head per household.

Swine raised and fattened in the backyard normally generate income every quarter of the year. Commercial swine production requires more labour and financial investment in breeders, sheds, equipment, and good farm management practices. The average number of swine is significantly different between NRM and MF systems, with 21 and 10 head respectively.

Poultry is the most important source of protein. Poultry is mostly raised in the backyard or mixed with livestock. The number of poultry was declined after the avian flu outbreak in 2004. The average number of chickens in NRM and MF systems is only 36 and 27 per household. The average number of ducks in NRM and MF system is only 29.

***Physical assets*** are assets created to fulfil basic human needs. Infrastructure, livestock shelters, machinery, instruments, and technologies are necessary for livestock production. More than 80% of farmers have adequate infrastructure facilities, except farmers in MF systems. Tambon Administration Organizations or Village Committees manage village water supply systems. The challenge is to reduce salinity and contamination levels. Electricity is expensive. Telecommunications, road networks, and transportation services are necessary for trade, access to social services, and exchanging information with outsiders. The quality of road links from sub-districts to villages is generally poor, and accessibility is more difficult during the rainy season.

Farm dwellings are constructed with local materials and mostly older than 20 years. Animal shelters have moderately good sanitation. The design and size of livestock shelters depends on the type and number of livestock, individual preferences, budget, and available materials. Poultry shelters and pigpens are built with sloping roofs made of local materials and the floors are often covered with rice straw and rice husks. Housing provides security to farmers and also livestock. Machinery is mostly old and rust is a problem due to the high salinity of the water in the area. Farmers will often borrow or rent machines and equipment from neighbours or relatives when needed. Whether or not a technology is adopted depends on its compatibility, a farmer's preference, and his/her production system (Johan, 2011).

Fodder cultivation is promoted to increase feedstuffs. Demand for commercial feed for non-ruminant production has increased because of convenience, nutritional value, and quality. The feed cost of swine rearing is 80% of the total cost of production. Some farmers minimize costs by mixing commercial feed with local ingredients, for example, kitchen waste and residue from cultivation, rice mills and noodle factories. Based on the field survey, the following practices have been observed. Local feedstuffs for poultry are rice bran, broken rice, and other cereal grains, worms, and insects. Minerals and vitamins are mixed with feedstuffs to improve animal health and growth rate. Effective microorganisms, or EM, have been introduced to resolve the problem of bad odours from livestock excretions, to increase effective digestion, and to treat wastewater and dung. Breeding via artificial insemination (AI) has been promoted to improve production and the genetics of local breeds. AI can help improve the livelihoods of livestock farmers by increasing animal products and conserving genetic diversity (Johan, 2011).

***Social assets*** influence other livelihood assets by promoting cohesiveness, security, and sharing systems. Social assets have a direct impact on the efficiency of economic relations, and the management of common resources (natural and physical assets), and facilitate innovation and knowledge sharing (DFID, 1999). Non-monetary exchange among farmers through their social networks creates opportunities to exchange livelihood assets such as labour, production inputs, information and knowledge about livestock production, and market accessibility (Prateep, 2006). Sharing assets and resources is part of traditional Thai culture and helps farmers solve farming problems, overcome capital shortages, increase livelihood security, and reduce the risk of outside dependency. Unfortunately, this sharing tradition is declining and is evident in all three farming systems.

Group discussions revealed that training and information shared by social groups helps increase farmers' abilities and expand their markets. Visiting markets at regular intervals for buying and selling merchandise and transacting marketing functions also increases social interaction that enhances social assets. Accessibility to markets depends on transport networks and types of livestock. Only 40% of interviewed farmers in RM, NRM, and MF systems visit markets regularly. Farmers mostly sell their livestock and livestock products to middlemen, mobile markets that come to or near their village, cattle-buffalo market fairs, slaughterhouses, and district markets.

***Financial assets*** are important for undertaking any livelihood activity. In terms of income generation, livestock farming provides income from direct sale of products and manure. The average income from livestock in NRM is approximately THB 158,280, which is higher than farmers in RM and MF systems, who earn

THB 86,590 and 125,870 per year respectively. It was found that some farmers earn a higher income from training and selling fighting cocks. The price of a good fighting cock is approximately THB 5,000-10,000. Animal dung generates bio-fertilizer, from 4 to 7 kg per head of cattle per day, and 2 kg per head of swine per day, and is sold at two Thai Baht per kilogram. Some farmers produce worms and grubs from non-ruminant animal dung to feed their poultry and fish, or they can sell it for 14-23 Baht per kilogram. Fodder cultivation helps farmers reduce feeding costs and generates supplementary income. However, 75-80% of the income is spent on livestock production.

More than 80% of farmers in RM, NRM, and MF systems have savings in the form of movable property, such as livestock, bank savings, cash, rice and grain or vegetable seeds, and vehicles. Farmers use their savings for investment in agricultural production, meeting emergency needs, and at times coping with economic vulnerabilities.

Regular inflow of money comes from credit, remittance income, and transfers from the state as subsidies or special grants. More than 75% of all farmers in the three systems are indebted. The Bank of Agriculture and Agricultural Cooperatives, Village Funds, Savings and Credit Cooperative Societies, and informal credit providers are the main sources of credit. For short-term debt (< 1 year) and medium-term debt (2-5 years), farmers in NRM systems have the highest debt (THB 35,000/debtor in short-term debt and THB 138,000/debtor in medium-term debt). RM system farmers have the highest average long-term debt (>5 years) with approximately THB 214,000/debtor. In MF systems, farmers have the lowest average short-, medium- and long-term debt (THB 28,000, 35,000, and 89,000/debtor). Farmers in NRM systems have greater accessibility to credit than farmers in other systems. More than 40% of all farmers in all three systems have high repayment ability.

A Livelihood asset analysis was done using a five-point Likert scale. Indices were computed for all five asset types and compared across the three systems. The index values of all five types of assets for each livestock farming system are depicted in pentagon graphs (Figure 2). In Figure 2, the three systems show a similar picture in terms of asset characteristics. The physical asset index (RM =0.74, NRM=0.74, and MF=0.70) appears to be high in all three systems with little variation between them. Financial assets appear to be the next most important after physical assets, with an index value that varies from 0.72 (RM) to 0.69 (NRM) to 0.69 (MF). Social assets are mid-range (RM=0.69, NRM=0.66, and MF=0.66), followed by natural assets (RM=0.66, NRM=0.68, MF=0.59). Human assets have the lowest index value for all three systems (RM=0.54, NRM=0.54, and MF=0.51).

The livelihood asset indices show that good physical and financial assets provide ample opportunity for expansion and intensification of smallholder livestock farming, whereas human assets and natural assets indicate some constraints. These findings have strong implications for strengthening natural assets vis-à-vis human assets. In terms of gross income and profit earned by smallholder farmers, the NRM system is the most profitable, followed by MF and RM systems. The limitations of human and natural assets are reflected in the gross income and net profit as well. This suggests that public and private sector agencies could be more proactive in supporting and facilitating smallholder farmers through training programs, provision of improved livestock farming information, and improving accessibility to public services to increase opportunities for additional and alternative livelihoods.

## Variables for measuring sustainability

A complex of inter-related factors in livestock farming influences growth, development and production (FAO, 1988). Variables for measuring sustainability are the independent variables, which were identified from farmers' livelihood assets during group discussion and the data collected from the household survey. Two types of variables were selected. The first type is common to the three farming systems and the second type is specific to different farming systems. Table 3 provides a list of the variables selected along with a brief description, value, and value label used for measurement.

*Common variables* were selected from human, social, natural, physical, and financial assets. Smallholders typically have higher profit per unit of output than large-scale producers, with and without costing of family labour (Nipon, 2013) hence, household labour is an important human asset for small farm activities. The number of household labourers, age, experience, health status, and accessibility to training and information were chosen to measure sustainability of farmers' livelihoods. Social security is a component of sustainable development and a main pillar of economic support and can be a determining factor for ensuring sustainable development (Răzvan-Dorin, 2012). Social participation and social security were selected as indicators as they provide opportunities. Accessibility to markets was selected as an indicator as it is related to social assets. El Mamuon (2013) found, for example, that market accessibility effects positive changes in social network building.

Land and water resources are essential natural assets (FAO, 2011), hence, land size, livestock rearing area, and soil and water quality were selected as indicators. Farmers who own land are more secure than those renting land. Legal title deeds issued to farmers give them full rights for using the land in their possession, and improved land access leads to improved household welfare (Winters *et al*., 2009). Farmers who own land can escape poverty more easily than those who do not (Lawal, 2011).

Soil fertility and water quality are important for livestock feeding, health, and productivity (FAO, 2011). Poor quality or inadequate feedstuff and water can all lead to low productivity, high toxicity problems, and high morbidity and mortality of animals. Physical assets include the quality of infrastructure services such as electricity, village water supply, telecommunications, and transportation, safety and sanitation of animal housing, and machinery and equipment (FAO, 1988; Lawal, 2011; Raj Khanal *et al*, 2014), all of which can indicate livestock production capacity. Livestock housing is mainly concerned with the physical environment, where healthy, high yielding animals can be provided with optimal feeding and can reproduce without stress or suffering physical harm (FAO, 2011).

 

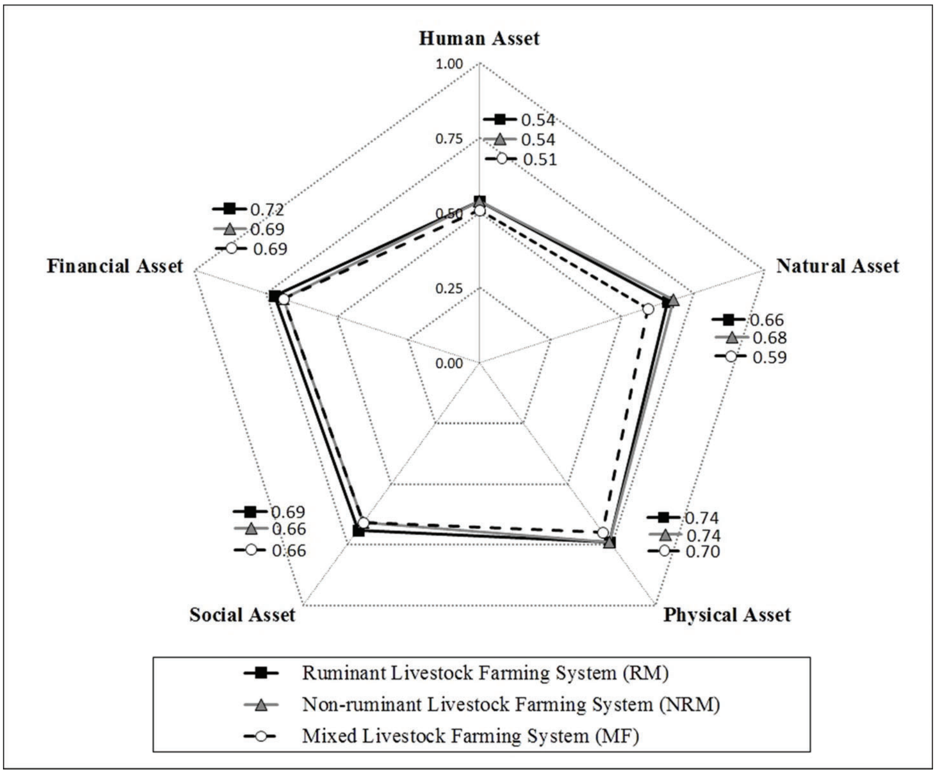


**Figure 2:** Livelihood asset pentagon of three livestock farming systems

Financial assets are used to achieve farmers' livelihood objectives, in the form of savings and credit, and regular inflows of money such as pensions, transfers from the state, and remittances (DFID, 1999). This asset category was assessed through: saving adequacy, loan accessibility, ability to repay loans, and income-expenditure ratio. Adequate savings provide opportunities for investment, and successful livestock farming increases savings. Loan accessibility and repayment ability indicate a farmer's liquidity, and income-expenditure ratio reflects the efficiency of the farm operation. If income is higher than expenditure, a livestock production operation is considered sustainable.

The number of livestock in each farming system is a specific variable. Ruminant systems consist of cattle and buffalo, non-ruminant systems swine, chickens, and ducks, and mixed livestock farming systems a combination of both ruminant and non-ruminant animals. The number of livestock should match the physical assets needed to generate maximum benefit to farmers.

## Results of linear discriminant analysis

Linear discriminant functions for smallholder farmers in each livestock farming system were calculated using SPSS. The magnitude of coefficients indicates how strongly the discrimination variables affect the score. However, a non-standardized coefficient does not clearly indicate the relative contribution of the variable to the overall discrimination when a variable is measured in different units. The variables selected for analysis are presented in Table 3. The standardized coefficients presented in Table 4 explain the relative importance of each independent variable for the three farming systems. Table 5 illustrates the contribution of independent variables in order of ranking, following the standardized coefficient values that explain sustainable livelihood.

### Linear discriminant functions for ruminant livestock farming ($D_{RM}$)

Equation (3) highlights the relative importance and contribution of variables reflected in coefficient values.

$$\begin{aligned} D_{RM} = & -30.953 + 0.044 \text{ Labourer} + 0.030 \text{ Age} \\ & + 0.951 \text{ Experience} + 0.201 \text{ Health} + 1.073 \text{ Training} \\ & + 0.034 \text{ Information} + 0.787 \text{ Participation} + 0.194 \\ & \text{Security} - 0.044 \text{ Ownland} + 0.041 \text{ Livestockarea} \\ & + 0.173 \text{ Soil} + 1.694 \text{ Water} + 0.032 \text{ Cattle} - 0.065 \\ & \text{Buffalo} + 0.497 \text{ Infrastructure} + 0.019 \text{ Safety} + 0.426 \\ & \text{Sanitation} + 0.063 \text{ Machine} + 0.876 \text{ Market} + 1.067 \\ & \text{Saving} + 0.090 \text{ Loan} + 0.259 \text{ Payment} \\ & + 2.713 \text{ I/ERatio} \end{aligned} \quad (3)$$

Note: Coefficients of variables are not standardized. $R^2$ is 0.696.

Classification results of 88 households using RM systems show that 96.60% of the original grouped cases are correctly classified. The standardized coefficient in Table 4 and 5 shows that income and I/E ratio has the greatest coefficient value and makes the highest contribution to improved or non-improved living status in RM systems.

Farmers need high net income for future investment and living expenses. The price of good breeds of cattle

**Table 3:** Description of variables in discriminant analysis

| Variable | Description | Value and value label |
|---|---|---|
| **Dependent variable** | | |
| D | Meaning of farmer livelihood | Non-improved living<br>Improved living |
| **Independent common variables** | | |
| **1. Human Asset** | | |
| Labourer | Number of household labourers | (Persons) |
| Age | Average age of household labourers | (Years) |
| Experience | Adequate experience for farming | Highly inadequate, Inadequate,Moderate, Adequate, Highly adequate |
| Health | Health status of farmers | Very poor, Poor, Moderate, Good, Very good |
| Training | Accessibility to training on livestock farming | Never, Rarely, Sometime, Often, Always |
| Information | Accessibility to information about livestock farming | Never, Rarely, Sometime, Often, Always |
| **2. Social Asset** | | |
| Participation | Participation in social activities | Never, Rarely, Sometime, Often, Always |
| Security | Social security level | Very poor, Poor, Moderate, Good, Very good |
| Market | Accessibility level to market | Very low, Less, Moderate, High, Very high |
| **3. Natural Asset** | | |
| Own land | Own land area | Rai (1 ha=6.25 rai) |
| Livestock area | Livestock rearing area (Stable/shelter and grazing area) | Rai (1 ha=6.25 rai) |
| Soil | Soil quality | Very poor, Poor, Moderate, Good, Very good |
| Water | Water quality | Very poor, Poor, Moderate, Good, Very good |
| **4. Physical Asset** | | |
| Infrastructure | Quality level of Infrastructure | Very poor, Poor, Moderate, Good, Very good |
| Safety | Safety of animal stable/shelter | Very poor, Poor, Moderate, Good, Very good |
| Sanitation | Sanitation level of animal stable | Very poor, Poor, Moderate, Good, Very good |
| Machine | Adequacy of machinery and Equipment | Highly inadequate, Inadequate, Moderate, Adequate, Highly adequate |
| **5. Financial Asset** | | |
| Saving | Adequacy of savings | Highly inadequate, Inadequate, Moderate, Adequate, Highly adequate |
| Loan | Accessibility to loans | Very less, Less, Moderate, High, Very high |
| Payment | Ability for loan payment | Very less, Less, Moderate, High, Very high |
| I/E Ratio | Income/expenditure from livestock production | Income-Expenditure Ratio |
| **Independent Specific Variables** | | |
| Cattle | Number of cattle | head |
| Buffalo | Number of buffalo | head |
| Swine | Number of swine | head |
| Chicken | Number of chickens | head |
| Duck | Number of ducks | head |

and buffalo are mostly higher than THB 40,000 per head. Income turnover for cattle is 1 to 2 years and for buffalo 2 to 3 years. Water quality level (Water) aids ruminant livestock digestion, increases health, pregnancy, growth, and productivity rates, especially during drought and low humidity periods. Social participation level (Participate) leads farmers to share resources in production, as well as offering farmers access to training and information, which contributes to their knowledge and capacity for strengthening their livelihood systems.

## Linear discriminant functions for non-ruminant livestock farming ($D_{NRM}$)

Equation (4) highlights the relative importance and contribution of variables reflected through coefficient values.

$$\begin{aligned} D_{NRM} = & -56.90 + 1.066\ \text{Labourer} + 0.045\ \text{Age} \\ & + 2.566\ \text{Experience} + 1.099\ \text{Health} + 0.439\ \text{Training} \\ & + 0.790\ \text{Information} + 0.663\ \text{Participate} + 0.855 \\ & \text{Security} + 0.038\ \text{Ownland} + 0.304\ \text{Livestockarea} \\ & + 0.893\ \text{Soil} + 2.277\ \text{Water} - 0.051\ \text{Swine} - 0.084 \\ & \text{Chicken} - 0.038\ \text{Duck} + 1.121\ \text{Infrastructure} + 0.139 \\ & \text{Safety} + 0.921\ \text{Sanitation} + 0.561\ \text{Machine} + 0.410 \\ & \text{Market} + 0.128\ \text{Saving} + 1.131\ \text{Loan} + 0.483 \\ & \text{Payment} + 6.589\ \text{I/ERatio} \end{aligned} \tag{4}$$

 

**Table 4:** Standardized canonical discriminant function coefficients

| Independent Variables | RM[1] | NRM[2] | MF[3] | Independent Variables | RM[1] | NRM[2] | MF[3] |
|---|---|---|---|---|---|---|---|
| **Common variables** | | | | | | | |
| Labourer | 0.012 | 0.187 | 0.258 | Soil | 0.039 | 0.150 | 0.161 |
| Age | 0.104 | 0.142 | 0.224 | Water | 0.396 | 0.411 | 0.195 |
| Experience | 0.295 | 0.492 | 0.092 | Infrastructe | 0.103 | 0.193 | 0.279 |
| Health | 0.031 | 0.102 | 0.196 | Safety | 0.007 | 0.036 | 0.074 |
| Training | 0.270 | 0.086 | 0.114 | Sanitation | 0.135 | 0.226 | 0.042 |
| Information | 0.010 | 0.165 | 0.202 | Machine | 0.040 | 0.218 | 0.139 |
| Participate | 0.331 | 0.223 | 0.300 | Market | 0.215 | 0.090 | 0.162 |
| Security | 0.054 | 0.251 | 0.380 | Saving | 0.266 | 0.040 | -0.001 |
| Own land | -0.108 | 0.066 | -0.324 | Loan | 0.034 | 0.262 | 0.100 |
| Livestock area | 0.099 | 0.117 | 0.038 | Payment | 0.167 | 0.216 | -0.094 |
| | | | | I/E Ratio | 0.521 | 0.431 | 0.775 |
| **Specific Variables** | | | | | | | |
| Cattle | 0.077 | None | -0.079 | Swine | none | -0.179 | -0.026 |
| Buffalo | -0.132 | none | 0.020 | Chicken | none | -0.571 | -0.322 |
| | | | | Duck | none | -0.157 | 0.240 |

[1] RM: Ruminant livestock farming system
[2] NRM: Non-ruminant livestock farming system
[3] MF: Mixed livestock farming system

Note: Coefficients of functions are not standardized. $R^2$ is 0.808.

Classification results of 52 households in NRM show that all the original grouped cases are correctly classified. The standardized coefficient values in Table 4 and 5 show that adequacy of experience for livestock farming (Experience) has the highest value and makes the greatest contribution to improved or non-improved living status of farmers. Animals in NRM are more sensitive to rearing practices compared to those in RM systems, which means farmers' experience is extremely important in NRM systems. Income-expenditure ratio (I/E ratio) and water quality (Water) variables have absolute standardized coefficient values higher than 0.40, hence they have a high impact on production and livelihood. Income turnover of non-ruminants is shorter than for ruminants, and production costs are higher. Feed cost is about 60-70% of the total production cost. The net return is low due to low product price and high input costs, and is common in NRM systems. Most NRM systems use village water supplies. During the dry season, water often becomes more saline and is unsuitable for non-ruminant animals. This has implications for animal health. The number of chickens has an absolute value of standardized coefficient higher than 0.40, while other factors are lower than 0.20. Increasing or decreasing the number of chickens influences improved or non-improved status of a farmer's livelihood.

## Linear discriminant functions of mixed livestock farming ($D_{MF}$)

Equation (5) highlights the relative importance and contribution of variables reflected through coefficient values.

$$\begin{aligned} D_{MF} = & -44.492 + 1.391\ \text{Labourer} + 0.083\ \text{Age} - 0.401 \\ & \text{Experience} + 1.076\ \text{Health} + 0.860\ \text{Training} + 0.968 \\ & \text{Information} + 0.768\ \text{Participate} + 0.979\ \text{Security} - 0.149 \\ & \text{Ownland} + 0.026\ \text{Livestockarea} + 0.894\ \text{Soil} + 1.004 \\ & \text{Water} - 0.018\ \text{Cattle} + 0.018\ \text{Buffalo} - 0.015\ \text{Swine} \\ & - 0.039\ \text{Chicken} + 0.060\ \text{Duck} + 1.388\ \text{Infrastructure} \\ & + 0.326\ \text{Safety} + 0.192\ \text{Sanitation} + 0.272\ \text{Machine} \\ & + 0.785\ \text{Market} - 0.003\ \text{Saving} + 0.304\ \text{Loan} - 0.168 \\ & \text{Payment} + 7.903\ \text{I/ERatio} \end{aligned} \tag{5}$$

Note: Coefficients of functions are non-standardized. $R^2$ is 0.750.

Classification of 65 households in MF systems shows that 95.40% of the original grouped cases are correctly classified. The standardized coefficients in Tables 4 and 5 show that income-expenditure ratio (I/E Ratio) has the greatest value and makes a strong contribution to improved or non-improved living status. Other variables such as social security, own land, and number of chickens have absolute standardized coefficient values higher than 0.30. For maintaining farmers' living expenses and future investment, farmers need high net income. Smallholder farmers in MF systems who have improved their living status mostly feel safe and secure within their community. Their animals are protected against theft while they are away from home, and when labour is in short supply. Farmers in MF systems need land to expand their livestock production and grazing area. Other livelihood assets, such as financial and social assets can support and sustain farmers' livelihood improvement in MF systems.

Based on the discriminant analysis, 47 farmers out of 88 (53%) in RM systems, 25 out of 52 (48%) in NRM, and 37 out of 65 (57%) in MF, have improved their living conditions. Overall, 109 out of 205 (53%) farmers achieved improved living status with livestock farming. Thus, livestock farming is a good alternative livelihood and the results suggest that livestock farming could be intensified in other parts of Thailand with similar conditions.

The potential contribution of livestock sector development to livelihoods of the poor is significant (FAO, 2016). The most important common factor for RM and MF systems contributing to sustainability is the

**Table 5:** Important factors for smallholder livestock farm sustainability

| Standardized | RM[1] | | NRM[2] | | MF[3] | |
|---|---|---|---|---|---|---|
| **Coefficients (Absolute Value)** | **Common variables** | **Specific variables** | **Common variables** | **Specific variables** | **Common variables** | **Specific variables** |
| >0.40 | I/E Ratio | | Experience<br>I/E Ratio<br>Water | Chickens | I/E Ratio | |
| 0.31-0.40 | Water<br>Participate | | | | Security<br>Own land | Chickens |
| 0.21-0.30 | Experience<br>Training<br>Savings<br>Market | | Loan<br>Security<br>Sanitation<br>Participate<br>Machinery<br>Payment | | Participate<br>Infrastructure<br>Labourer<br>Age<br>Information | Ducks |
| ⩽0.20 | Payment<br>Sanitation<br>Own land<br>Age<br>Infrastructure<br>Livestock area<br>Security<br>Machine<br>Soil<br>Loan<br>Health<br>Labourer<br>Information<br>Safety | Buffalo<br>Cattle | Infrastructure<br>Labourer<br>Information<br>Soil<br>Age<br>Livestock area<br>Health<br>Market<br>Training<br>Own land<br>Saving<br>Security | Swine<br>Ducks | Health<br>Water<br>Market<br>Soil<br>Machinery<br>Training<br>Loan<br>Payment<br>Experience<br>Security<br>Sanitation<br>Livestock area<br>Savings | Cattle<br>Swine<br>Buffalo |

[1] RM: Ruminant livestock farming system
[2] NRM: Non-ruminant livestock farming system
[3] MF: Mixed livestock farming system

income-expenditure ratio and for NRM systems, the most important factor is farmer experience with livestock rearing. Generally, non-ruminant systems are more sensitive to the physical environment than are ruminant systems. Experience and knowledge are therefore critical.

## 4. Conclusions

The livelihood pentagon analysis reveals that some variation exists among the livestock farming systems in terms of asset structure. Overall, physical and financial assets are indicative of strength and potential, whereas natural and human assets are indicative of weaknesses and limitations. Social assets fall between these two sets of assets and offer ample scope for integrating with and contributing to other assets. Considering all assets, the key factors influencing livestock farming and its sustainability are linked with income-expenditure ratio (net income) for RM and MF systems, and experience of farmers engaged in NRM systems. The linear discriminant function analysis revealed that more than half the farm operations are sustainable. This analysis can also predict the livelihood status of new smallholder farmers in RM, NRM and MF systems in terms of either improved or non-improved standard of living and the sustainability of their livelihoods.

Income-expenditure ratio (net income) and experience of smallholder livestock farmers in this region can be increased through training programmes and provision of improved livestock production information. Training and information should be available to all interested smallholder farmers and should focus on farm management, pricing and marketing, and technology for breeding and for disease protection. The concerned agencies, particularly government and non-government organizations, the private sector, and local organizations could be more proactively involved in terms of policy planning, project formulation and implementation in line with the identified factors.

Finally, the outcomes of this study have policy implications for decision makers, planners, practitioners, extension agencies, and farmers by offering appropriate options for integrating livestock farming with livelihood systems. Alternatively, it could help farmers select a livestock production system given their livelihood assets.

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