Impact of market forces on product quality and grassland condition

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ABSTRACT

Meeting demands for livestock products which are predicted to more than double during the next 20 years, is central to the challenge of feeding the world sustainably. Smallholders will play a key role in achieving global security in animal protein. However, this requires a shift from subsistence to market-oriented farming where production efficiency not the number of livestock is the key focus with the aim of producing 'more from less'. For grassland-based ruminant production, reducing stocking rate from current unsustainable levels under subsistence management is an essential first step to producing more production and profit from fewer animals. This is made possible in commercial farming by using a combination of new technology, decision-making skills and market development. For example, only after stocking rate is sustainably aligned with forage supply and herd structure is changed to comprise mainly breeding females' can smallholders reliably use genetics and improved breeding programs to boost profitability by producing higher take-off of products that meet market quality specification. To link effectively with the market smallholders must be confident they can produce the quality products consumers want. Examples from Sunan County, Gansu Province, China, are given of the use of bio-economic modelling base on smallholder available feed supply to identify the best enterprise and management options to produce marketable quality products. However, poorly developed product specifications, poor price transparency, a lack of marketing services and inadequate infrastructure which still pose a major constraint to the transition from subsistence to commercial farming in developing countries requires remedial intervention. The highly integrated Australian sheep production and marketing system is briefly describes as an industry case study of how the combination of investment in R&D to develop new technologies such as Australian Sheep Breeding Values and breeding systems using terminal crosses are used to meet to continuing changing demands of domestic and overseas consumers. This case study provides principles and practices that can be applied to improved production efficiency and marketing in developing countries to facilitate the transition from subsistence to market-oriented ruminant production.

Keywords: ASBVs, Genetics, Grasslands, Markets, Sheep production, Sustainability

Introduction

By 2050, the agricultural sector has the huge challenge to produce 60% more than the current food, feed and fibre supply of 8.5 billion t/yr to sustain a global population of 9.3 billion people (FAO, 2014). It will not be possible to achieve this level of production and, at the same time safeguard the planet's natural resources for future generation, without fundamental changes to our agriculture production and food processing systems. No longer can countries simply open up new agricultural land to increase supplies to meet food demands because agriculture is already competing for limited land and water resources with rapidly expanding urban settlements. Rather, the global food system will have to improve its resource use efficiency and its environmental performance significantly to ensure the sustainability of global food production and consumption (Herrero and Thornton, 2013). This means a concerted effort must be made to develop new technologies and improve farmer managerial capacities to empower them to sustainably "produce more from less" within a rapidly changing market-oriented and competitive farming environment (FAO, 2009).

By definition, sustainable agriculture conserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. This transition to sustainable food and agriculture systems will ensure world food security, provide economic and social opportunities, and protect the ecosystem services on which agriculture depends (FAO, 2014). However, this transition requires a paradigm shift for much of the world's agriculture from traditional subsistence farming which is no longer economically or environmentally viable due to increasing population to market-oriented farming. Even small-scale farmers who produce food primarily for the needs of their families now require cash to sustain their livelihood and are faced with the imperative to be market-oriented and operate their farms as 'emerging businesses' using the same principles and approaches as corporate farming (Kahan, 2013).

The demand for livestock products, predicted to more than double during the next 20 years (Thornton, 2010), is central to the challenge of feeding the world sustainably (Herrero and Thornton, 2013). For grassland-based ruminant production, this transition from subsistence to a small business focus offers an important opportunity to promote the adoption of technologies and practices that increase productivity and improve resource use efficiency (FAO, 2011). This not only provides a solution to the challenge of feeding the world sustainably by producing more product and profit from fewer animals, but can potentially repair the severe grassland degradation that has occurred through the prevailing strategy of maintaining large livestock numbers in an effort to alleviate poverty in subsistence households (Briske *et al.,* 2015).There is unequivocal evidence that technical improvements, often used as part of sustainable intensification strategies, lead to increases in livestock productivity and efficiency with larger effects evident in systems where productivity is low (Kemp *et al.,* 2011; Herrero and Thornton, 2013).

This highlights the importance of smallholders in meeting global demands for animal protein because the potential for increasing productivity and efficiency of more than 1 billion smallholder livestock producers in the developing world is far greater than in the developed world (Herrero and Thornton, 2013). However, it is not simply a case of producing more output by raising more livestock as this will only further degrade grassland and deplete ecosystem function which, in turn, will reduce food supply and income, thereby continuing the vicious cycle of further degradation and poverty of smallholders (United Nations, 2013). Rather, to transform smallholders into sustainable livestock farmers requires not only technical solutions to production questions, but knowledge and skills to manage competitive and profitable livestock enterprises. These new skills include: managing input, managing production and managing marketing; all of which are needed to implement sustainable market-oriented farming in which product quality and production efficiency are the key drivers (Kahan, 2013).

This means smallholders livestock producers must be aware of consumer demands and the needs of the market to guide their decisions on what to produce rather than *ad hoc* selling of any surplus from the traditional production of food for their household consumption. Consumer demands and expectations concerning food preferences, quality, variety and safety differ significantly from the rural societies who produce the food (Henriksen and Rota, 2014). If developing countries are to capitalise on the rapidly growing global demand for livestock products, smallholders in particular must have sustainable access to markets for produce, inputs and credit to stimulate the uptake of already existing technology that will greatly increase output per hectare and return to labour (Wiggins and Keats, 2013), and effectively producing 'more from less'.

This paper will describe some of major constraints limit competitiveness of smallholders and hinder their participation in profitable livestock value chains due to current production systems using examples from the grassland steppes of China. As a major exporting nation, Australia has developed highly integrated production and marketing systems that provide a case study of how adopting new technology and maintaining a strong market focus has revolutionised the sheep industry to produce 'more from less' and at the same time improve the environment. Many of the precision management principles and technologies used in Australia can be readily adopted by emerging commercialised livestock industry in the developing world.

Managing the transition from subsistence to commercial livestock production

The aim of livestock production is to transform natural resources into meat and fibre for human use and improving the efficiency of this process is crucial to sustainable agriculture (FAO, 2014). Rota and Sperandini (2010) define *sustainable livestock production* as raising animals using a system that favours the long-term availability of the inputs necessary to continue in operation, along with satisfactory returns for the farmer whereas unsustainable practices are those that cause damage to the environment and increase the risk of disease. This means that sustainability requires direct action to conserve, protect and enhance natural resources, and at the same time, protect and improve rural livelihoods, equity and social well-being (FAO, 2014). In short, sustainable livestock production systems must be profitable, ecologically sensible and socially acceptable.

Adjusting stocking rate and feed supply

One of the key drivers of sustainability is stocking rate. Unfortunately, many of the world's grasslands are now seriously degraded due mostly to overgrazing (O'Mara, 2012) because farmers (both small and large) have thought that they could increase their profit by grazing increasing numbers of animals. The key relationship is one of diminishing returns, as the number of animals per unit area increases, the available forage per animal decreases which results in production per animal declining and production per hectare rising, then falling once animal production per head is half of their potential (Fig. 1). The economic optimum stocking rate is often found around Point A where the production per hectare is 75% of the biological optimum. However, the same level of production per hectare occurs at Point B and subsistence farmers are often at this point. Animals stocked at Point A are producing at 75% of their potential per head whereas those

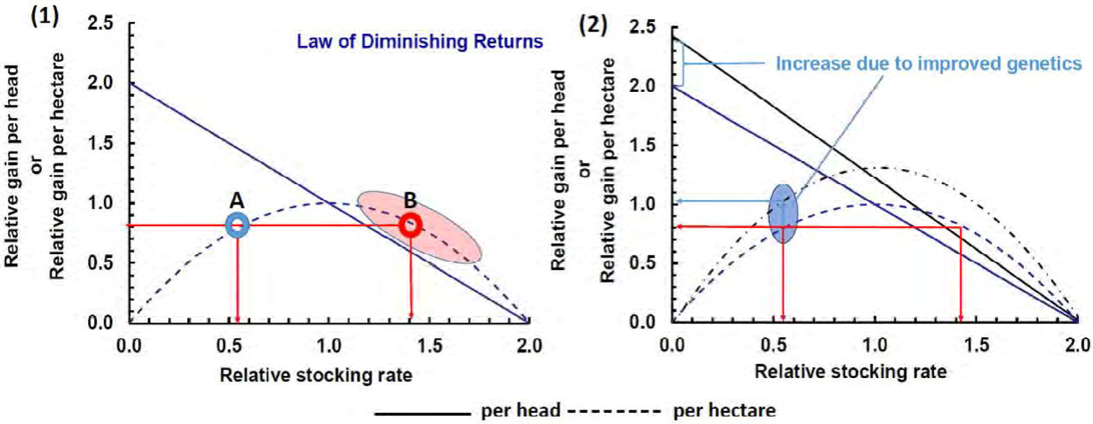

Fig. 1. Basic relationship between stocking rate and livestock production (based on Jones and Sandland, 1974). (1) Points A and B are where production per hectare is 0.75 of the biological optimum; (2) Change in production at Point A when genetics are used to improve livestock growth rate by 20%.

at Point B only at 25% which means that animals at Point A would grow to target market weight in one-third of the time of those at Point B (Kemp *et al.*, 2015). In developing countries, animal growth rates are often considerably lower than their potential.

This clearly shows that it is not possible for farmers to meet the age, weight and quality specifications of developing urban meat markets when their herd size is too large to be sustained by their forage resources. This is most often the case for subsistence grass-fed livestock systems where increase in livestock number rather than production efficiency is the strategy used to sustain household income; a strategy which has caused widespread grassland degradation and its associated environmental problems. For example, in China, statistics indicate that the current livestock numbers grazing China's grasslands are more than double the number considered to be the safe carrying capacity, and now more than 90% of the grassland is degraded (Han *et al.*, 2008). Since many farmers are grazing forage resources well beyond the economic optimum and since feed shortage is a major constraint common in most livestock production systems, it is safe to significantly reduce stocking rate and achieve the same output per hectare. This will provide farmers with the greatest opportunity to increase profit by producing a more valuable products for an identified market with improved forage availability and quality per animal, as well as help foster grassland regeneration by building plant reserves to survive the winter or dry season (Kemp *et al.*, 2011). Local research is needed to resolve which are the better grazing tactics and strategies to facilitate grassland regeneration.

Genetic improvement and breeding

Reducing stocking rate also provides an opportunity to change the herd through selective culling to a more commercial structure in which the number of breeding females is maximized. This contrasts with subsistence herds which tend to include a high percentage of non-reproductive older animals (*e.g.* mature castrated males) and mixed species (*i.e.* cattle, sheep, goats and camels) which are used for household security, status and household food. Simple management procedures such as tagging to identify ewes and their offspring, and recording of key performance information (*e.g.* live weight, body condition, lamb growth rate) are central to identifying non-productive ewes for culling (Michalk *et al.,* 2011). Kemp *et al.,* (2011) developed a 'precision livestock management tool' (PLMT) for western China which uses this individual animal performance information to estimate the value of individual animals so that they can be rated from best to worst, and the least productive animals culled. This increases net household income by significantly reducing input costs and significantly increasing reproductive performance at a lower stocking rate.

Only after stocking rate is sustainably aligned with forage supply and herd structure is changed to comprise mainly breeding females' can smallholders reliably use genetic improvement and objective breeding programs to boost profitability by producing higher take-off rates of products that meet premium quality market specifications (Kosgey and Okeyo, 2007). Reproduction rate, offspring growth and carcass quality have a major influence on livestock profitability. While different nutritional and husbandry practices can positively affect these traits, the potential change depends on environmental conditions whereas genetic improvement of the traits is permanent, cumulative, cost-effective and sustainable (Montossi *et al.,* 2013). Fig. 1(2) shows that a 20% increase in relative gain per head achieved by infusing improved genetics into the breeding program would increase gain per hectare by a similar amount.

Identifying animals with superior traits from the genetic pool available can be challenging and confusing, especially in developing countries where the shift to meat production in the transition from subsistence to commercial livestock farming influences genetic selection. This is evident in an over-emphasis on the introduction of higher-yielding exotic breeds from the developed world to use in cross-breeding systems and little focus on maintaining purity of indigenous genetic resources, the vast majority of which is kept by smallholder farmers under traditional management systems (Ayalew *et al.,* 2003). This has certainly contributed to the erosion of local breeds adapted to the lower input mixed farming and pastoral production systems found throughout the developing world (ILRI, 1999). Since the overall benefits of exploiting complementarities of different breeds and heterosis are dependent on the genetic merit of the pure breeds available (Montossi *et al.,* 2013), it is important in the transition from subsistence to prodsuction farming to conserve the purity of indigenous breeds, especially as the use of cross-breeding becomes more popular. Australia has developed integrated breeding systems to maintain purity of Merino as the maternal side of prime lamb production as described below.

Identifying the best enterprise and management practices

Matching livestock demands with available feed supplies is the key to efficient livestock production. In the transition from subsistence to market-oriented livestock production it is opportune to consider if changing the enterprise, management practices, or a combination of both, would result in a better use of available feed supply to improve efficiency and maintain or improve household profitability. Bioeconomic modelling based on household production data and current prices is a reliable and well-developed tool to evaluate alternative livestock enterprise and/or management options (Takahashi *et al.,* 2011). Examples of the use of modelling to evaluate alternative enterprises and management options for smallholders in

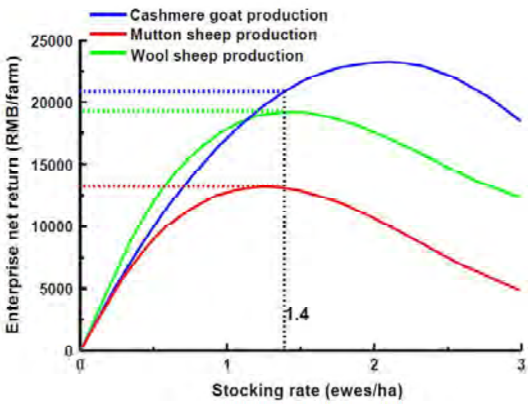

Fig. 2. Predicted effects on net livestock financial returns from changing livestock enterprises in Sunan Country, Gansu Province, China (Michalk et al. 2011). The vertical liens indicated current stocking rates.

Sunan County, Gansu Province (China) are given in Figures 2 and 3.

In Sunan County, fine wool production is the traditional enterprise, but there is growing interest in mutton sheep and cashmere production. Modelling showed that at the optimal stocking rate for fine-wool sheep, a change to mutton sheep would potentially reduce net farm return by more than 30% (Fig. 2). At the optimal net farm return for fine-wool sheep no significant reduction in stocking rate or increase in net farm return would be achieved by changing to cashmere goats. This confirms that fine-wool production is the enterprise better suited to Sunan County (Michalk *et al.*, 2011) and provides confidence for farmers to continue with fine wool as a commercial enterprise.

A farm survey found that January is the traditional lambing time in Sunan County (Yang *et al.*, 2011) which was a result of traditional nutrient cycles from grasslands and timed to ensure that lambs were sold before October to minimise the amount of supplementary feed required over winter. However, increased consumer demand for meat provides both motivation and opportunity to modify the traditional lambing schedules (Notter 2008). The modelling

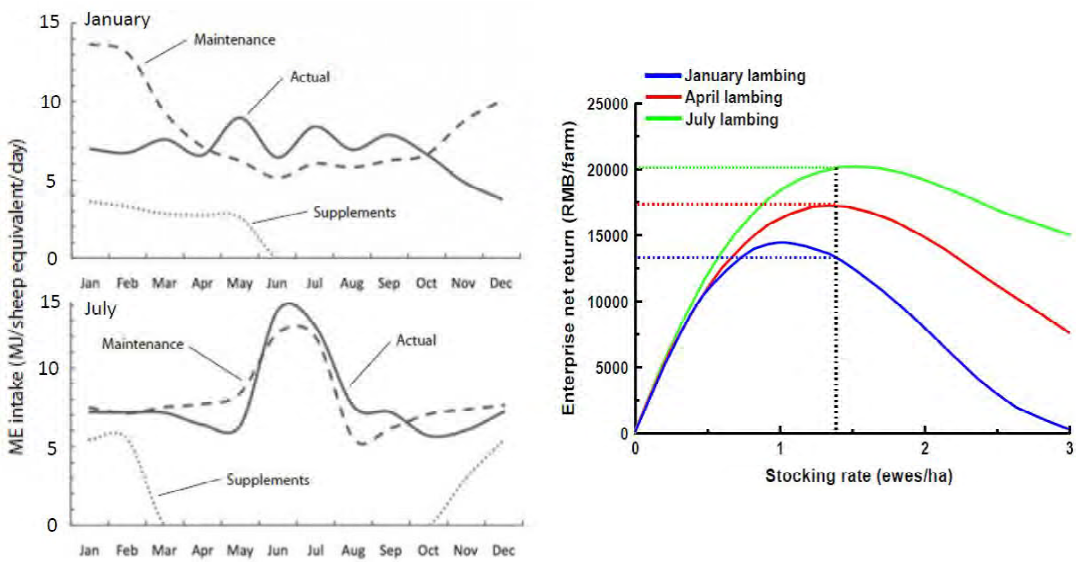

Fig. 3. Predicted effects on feed energy balance and net livestock financial returns from changing lambing time in Sunan County, Gansu province (Yang *et al.*, 2011).

highlighted a mismatch between livestock energy demands and current feed supplies to support winter (January) lambing practices whereas changing lambing to July better aligns sheep demands with forage supply (Fig. 3). Lambing in late spring means that ewes and lambs gain more benefit from green grasslands than at other times (Yang *et al.,* 2011). These examples highlight the importance of system analysis to identify the best enterprise and management pathways to increase livestock productivity and consequently the competitiveness of smallholder farmers as they transition from subsistence to commercial farming to supply the new, high-value domestic and international markets (Swanson, 2009).

Identifying the best product to market

In addition to new technical skills, market-oriented production requires an understanding of markets and their demands. This requires market analysis to identify the range of product options that can be realistically produced with farmers' resources and the key market specifications that must be achieved for each to meet the demands of consumers. Since farm produce sold on the market must be of sufficient quantity, quality and appearance to be able to compete with similar products from other local, domestic and international suppliers, farmers need to satisfy these demands and generate profits (Kahan, 2013). They need the knowledge and skills to calculate their production costs, and market information to formulate selling strategies based on price trends. However, poorly developed product specifications, inadequate market information evident in poor transparency in prices, a lack of core marketing services and infrastructure, and high transaction costs, all pose a major constraint on the transition from subsistence to commercial farming in many developing countries.

These inadequacies create the potential for market failure and highlight the need for some form of remedial intervention (Waldron *et al.,* 2011). However, if the operation of markets could be rapidly improved in developing countries, evidence indicates that the market can function as a control mechanism to limit stocking densities when the profits received by farmers from growing animals faster and producing heavier, better quality carcasses exceed those generated from current production systems (Harris 2010).

Australia's sheep industry: An example of 'more for less'

The concepts presented in this paper of the potential benefits of a transition from subsistence to commercial farming are underpinned by an analysis of basic animal production relationships which identify that substantive reductions in stocking rates would lead to higher productivity per head, with consequent increased ability to attract price premiums for better quality livestock products. The question is does this work in practice?

The evolution of the Australian prime lamb industry during the period 1980–2015 clearly shows that Border Leicester rams and the use of new precise and accurate technologies based on individual sheep performance increased productivity and efficiency so now more meat and wool output is produced that generates higher profit with significantly fewer sheep ('more for less'). In 2013, Australia had ~72 million sheep raised on 43,000 farms to produce a total sheep carcass weight (cw) of 640,000 t and 350,000 t greasy wool (Fig. 4) compared to ~150 million sheep in 1980 which produced 530,000 cwt t (ABS, 1982; ABARES, 2013). Since 1970, the Australian sheep flocks has declined from 180 million to 75 million; a 60% reduction. The industry was negatively affected during the

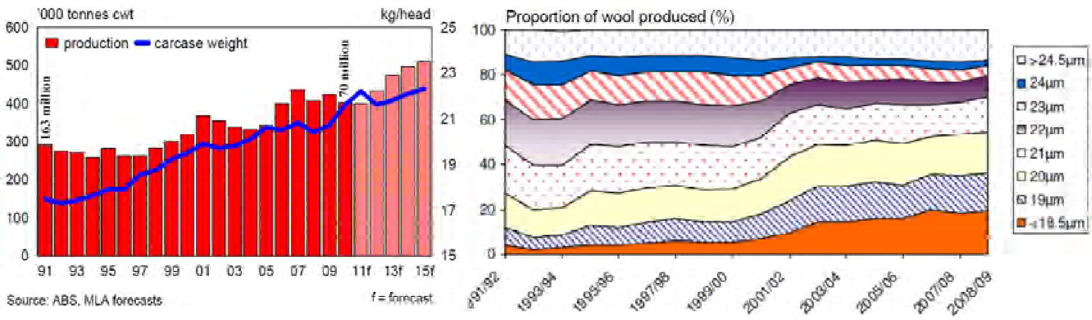

Fig. 4. Changes in sheep meat production, carcase weight and wool quality, 1991 to 2009 (ABS, MLA forecasts).

80s and early 90s by the low wool prices received by farmers, and began a slow recovery in the late 90s (Banks 2003). However, from 2000, the sheep industry has experienced an

exceptional growth due to investment in research and development focused on identified profit drivers for wool (*i.e.* clean fleece weight, fibre diameter, staple length, colour, strength and low contamination) and meat (*i.e.* reproductive performance, lamb growth rate, fat depth and meat quality) to consistently and efficiently meet the demands of Australia's domestic and export markets. Since >70% of all breeding ewes in Australia are fine wool Merinos, scientists and farmers have concentrated on selecting for both wool and meat traits to maximise farm income as both wool and meat are equally important to profitability (McEachen *et al.*,, 2014).

Genetics gain and the importance of Australian Sheep Breeding values

Genetic selection focused specifically on these identified profit drivers has increased productivity and product quality by 4% per annum from the late 1990s, generating a very competitive heavy, lean (<10 mm fat depth at GR site) lamb carcasses (18–22 kg) and wool yield of Merino ewes have increased by 20% (now 5kg greasy wool/sheep) and reduced fibre diameter by 2?m (Banks, 2003; Badgery *et al.*, 2015). Reproductive rate has also been increased with high fecundity Merino ewes producing >1.3 lambs/ewe joined. This not only can increase production by ~25%, but can reduce net farm greenhouse gas emissions by 21% compared to standard Merino ewes grazed at the same long-term stocking rate (Ho *et al.*, 2014).

Advances in our understanding of genetics means that Australian farmers can purchase rams based on their estimated Australian Sheep Breeding Value (ASBV) derived from the measured performance of their offspring for the genetic traits important to productivity (*e.g.* birth weight, growth rate) and product quality (*e.g.* carcase weight, post weaning fat). This 'genetic passport' specifying potential for genetic gain is more important than phenology because two rams can look similar and cost about the same but produce offspring with vastly different economic benefit to the farmer (Table 1). With the $A15 per progeny advantage, the superior ram would produce a $A4500 benefit in performance to yearling age if it sired 300 lambs in its lifetime plus the additional benefit over the lifetime of retained ewe progeny and the genetic advantage they will pass on to their progeny (Ferguson, 2015). This is a substantial economic benefit gained by the farmer simply by using the genetic information (ASBVs) to select sires.

Table 1. Average performance of 50 progeny from two rams with different ASBVs for post weaning weight (PWT), yearling greasy fleece weight (YGFW) and yearling fibre diameter (YFD) bought at auction and single sire mated to similar ewes (After Ferguson, 2015)

Ram number	8500	8600
Price at auction	$A1250	$A1100
ASBV		
PWD	+6.8 KG	+3.5 KG
YGFW	+10.8%	+3.8%
yfd	+0.3 µm	+0.1 µm
Average progeny performance		
Weight at 7 months	48.8 kg	43.7 kg
Fleece weight at 12 months	5.0 kg	4.6 kg
Fibre diameter at 12 months	18.6 µm	18.84 µm
Fleece value (2011 prices)	$A56.10	$A105.75
Total value (per progeny)	$A174.20	$A158.60

ASBVs also enable farmers to tailor lamb production to meet the specifications of carcase weight and fat depth for different markets (Fig. 5) developed by Meat Standards Australia™ (MSA)(MLA, 2012). These specifications have driven improve-ments in product quality and allow the sheep meat industry to target higher value domestic and international markets. This means that unlike the past when Australian farmers produced bulk meat, they now use precision management which combines genetic selection and specific feeding strategies to supply lamb to this differentiate grid as carcase conformation, tenderness and flavour are paramount to being competitive on the global market. MSA has generated substantial premiums for all participants in the supply chain (Griffith and Thompson, 2012) and has contributed to industry maintaining the long-term average productivity growth of approximately 0.5% per year in sheep enterprises because producers focus their efforts only those products that can be efficiently and consistently produced with forage resources of their farms and be compliant with statutory and customer-specific requirements.. Many believe (*e.g.* Gardner *et al.*, 2006) that the Australia sheep meat industry can implement further improvements through the strategic and intensive use of these genetic tools combined with monitoring of individual performance. Measuring, monitoring, and processing animal performance collected by farmers to select the most productive individual is a key to remaining competitive as up to 20% of animals in many flocks may contribute little to productivity and profitability (Rowe and Atkins, 2006).

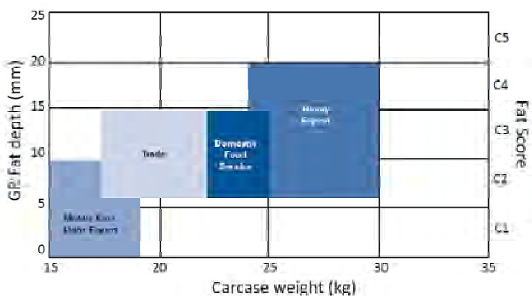

Fig. 5. Australian sheep meat specification based on carcase weight, fat depth at the GR site and sheep condition score (MLA/AWI, 2008).

Breeding systems using terminal crosses

Since meat from Merino lambs is darker and less stable in colour, farmers often use meat breeds (*e.g.* Border Leicester, Dorset, Suffolk, Dorper) as terminal sires in breeding systems to improve both meat quality and lamb growth rate. Heterosis is an important contributor to productivity from cross breeding. For example, weaning weights for lambs produced from a Border Leicester-Merino cross or a Dorset-Merino cross will be 15% and 25% higher than a Merino-Merino lamb at weaning. However, since Merinos provide wool which is far superior to meat sheep, farmers run parallel breeding systems that join Merino with Merino to maintain a pure Merino breeding flock and join other Merino ewes to Meat breeds to produce prime lamb. Alternatively, farmers may purchase replacement Merino ewes from specialised Merino breeding farms. On most farms, all lambs from Merino ewes jointed to meat breeds are sold as prime lamb, and in cases where farmers do joint first-cross ewes to terminal meat breed sires, all offspring are sold for meat. It is crucial that developing countries adopt this principle of maintaining purity of the maternal bloodline to conserve the adaptability traits of their indigenous breeds.

Monitoring markets and responding to changes in consumer demands

As the world's largest exporter of fine wool (<20?m) and sheep meat, Australian producers must respond quickly to changes in demand for and quality of these commodities to stay internationally competitive. Constant surveillance of who buys Australia's sheep products and continued monitoring of the specifications of what consumers want is done by industry-based R&D corporations, funded jointly through levies on sales of sheep and wool sales and matching government grants (Badgery *et al.,* 2015). For the sheep industry, Meat & Livestock Australia (MLA) and Australian Wool Innovations (AWI) provide Australian producers with timely intelligence on short- and long-term changes in global markets and provide them with more efficient science-based management practices (*e.g.* LambPlan, GrazFeed) to meet the quality expectations of consumers in existing and emerging markets. These industry organisations also run marketing campaigns to promote Australian livestock products in domestic and international markets.

An additional marketing strength of Australian agriculture, especially the red meat and dairy industries, is the disease free, 'clean and green' status (including maintaining high animal welfare standards) of exports achieved through the combined effort of producers, processors, exports and government. The adoption of the National Livestock Identification System, which requires cattle to be given an electronic identification ear tag at an early age and sheep to be identified by a property identification code, provides lifetime traceability as any animal progresses through the supply chain. Traceability also provides confidence to Muslim consumers (especially Indonesia and the Middle East) that meat exports are prepared, handled, packed and stored in a manner that addresses Halal integrity at all stages of production as specified by the Australian Government Halal Slaughter Program (MLA, 2015).

Impact of reduction of sheep number of grassland condition

This change in farming practice from the traditional philosophy of 'more livestock means more money' to 'more money from less livestock' has had positive impact on grassland condition and GHGs. The reduction in Australia's sheep flock has significantly improved grassland condition through increases in standing biomass, higher ground cover and enhanced biodiversity (Badgery *et al.,* 2015). In turn, there has been a six-fold reduction between the 1940's and 2000's in the average frequency and intensity of wind erosion activity which equates to a Dust Storm Index 23 times lower in the capital cities of southern Australia located adjacent to the temperate grasslands where most sheep are raised.

Farmers are now assessing feed-on-offer in sown forages and natural grasslands using a number of techniques including visual assessments, pasture probes and rising plate meters as part of integrated management programs (*e.g.* Prograze). This enables farmers to not only budget forage usage better to ensure that product quality specification are achieved, but also to improve environmental management which is closely linked with productivity and profitability. Since markets will place increasing pressure on farmers to continue to adopt best management practices and specialised breeding systems using the best genetics to premium products with even higher quality specifications, there are strong expectations that grassland condition, soil environment and water use efficiency will further improve (Ghahramani and Moore, 2015).

Conclusions

This paper has considered the opportunities available for smallholders to benefit from the growing global demands for red meat by changing from subsistence to commercial farming. Although smallholders currently raise the majority of the world's cattle, sheep and goats, it is unlikely that the substantive reductions in stocking rates identified by an analysis of animal production relationships (Fig. 1) can be achieved to increase production efficiency and improve product quality to meet world demands without a transition to market-oriented livestock production. By considering change in livestock enterprise to better match feed resources, change to management of current enterprises and/or change to feed supply, households have the potential to achieve significant stocking rate reductions without incurring any penalty in net farm income. In addition to increasing red meat production with fewer animals, as shown by the Chinese and Australian examples, the adoption of reduced stocking rates provide the opportunities to rehabilitate grasslands and improve environmental services.

It is clear that a combination of new technology, decision-making skills and market development are central to achieving sustainable livestock production. Since an extensive portfolio of genetic and management technology is already available from Australia (as detailed above) and elsewhere, the foremost challenges in promoting market-oriented sustainable livestock practices is to first change the mindset of herders and farmers from an emphasis on livestock number to productivity as their production goal (Wu *et al.,* 2011). Only then is it possible to use tailored education and targeted training to build new skills and build self-confidence to a level where farmers are willing to take the risk and apply new technologies to a competitive, market-oriented livestock context.

Continuous knowledge transfer and exchange of experiences between farmers, agricultural trainers and scientists should accompany this process to build locally adapted solutions since in all countries farms perform at substantially different levels with the bottom 25% of farms delivering much poorer yield and profit outcomes compared to the top 25%. Lifting performance, particularly for the middle 50% of farms, towards the levels achieved by the top 25% will be critical to increase productivity growth and efficiency to level to supply future market opportunities. To involve farmers in a process of education and exchange from the very beginning will influence the rate at which of farmers transition to market-oriented livestock production systems.

Markets are already providing price premiums for animals that produce more of the better quality meat demanded by consumers in countries like China (Michalk *et al.,* 2011). However, in China and elsewhere in much of the developing world, markets for livestock products are still poorly developed and remain chaotic, fragmented and small scale (Brown *et al.*, 2011). For markets to emerge as the driving force of the commercialisation process, substantial resources need to be invested to establish marketing infrastructure, improve price transparency through efficient market information systems and develop clear specifications for product quality and food safety that reflect consumer expectations. A major strength of the livestock market system in Australia is that farmers have been central to its development by contributing funding through their industry levies (CRRDC, 2010). This means that Australian livestock producers are significant players in the value chains for livestock products supplying domestic and international markets. It is an imperative that smallholders in developing countries replicate this Australian experience and develop viable and strong farmer organisations to avoid being excluded from the value chains, and as a result, miss a great potential for rural economic growth through market-oriented livestock production (Henriksen and Rota, 2014).

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