


Advances in smallholder large ruminant production and profitability in Southeast Asia over the past decade – lessons from the Mekong region: a review

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ABSTRACT

The global demand for protein in the form of red meat is growing, especially in Southeast Asia, with income and population growth driving an increase in global beef consumption projected to continue from 2023 to 2032. This provides incentive for smallholder large-ruminant producers to build on production improvements obtained over the past decade to ensure long-term profitability and sustainability. This review aims to provide an update on advances in smallholder large-ruminant production and profitability in Southeast Asia over the past decade, as well as highlight ongoing challenges that require further investment from governments and the private sector to meet the growing regional and global demand for protein that is safe for human consumption. Improvements are discussed in detail across the areas of health, production and welfare, using outputs from research for development projects across Southeast Asia, specifically Cambodia and Laos which have high proportions of population living below the national poverty line. Areas covered include nutrition, disease control, diversification and farmer engagement. Ongoing challenges and opportunities are also considered. Key improvements in smallholder large-ruminant production, health and welfare in Southeast Asia over the past decade include the introduction of strategies to improve nutrition through forage utilisation and disease control through vaccination and biosecurity as well as farmer engagement and diversification. However, major challenges continue in the areas of disease control and eradication, training, climate variability, gender empowerment and policy. Increasing global demand for red meat places smallholder large-ruminant producers throughout Cambodia and Laos in an ideal position to capitalise. To do this and gain improved regional food security requires ongoing investment in stakeholder training and adoption of appropriate strategies to ensure greater productivity from existing numbers and resisting increasing numbers in an environment with limited resources. Although the challenges for large-ruminant smallholders are substantial, the rewards for continual investment to improve health and production include increased household incomes and profitability as well as greater regional food security.

Keywords: biosecurity, food security, forages, health, livestock, markets, production, ruminants, smallholder, Southeast Asia, vaccination, welfare.

Introduction

Food security throughout Southeast Asia is an ongoing priority for developing and developed countries alike, with major investments in research for development projects aimed at improving smallholder farmer production and profitability. It is widely recognised that access to animal-source food is required to achieve good human health and nutrition (Alders 2023). Traditionally, meat from chickens and pigs complemented rice-based diets. However, the small amounts of meat consumed limited access to quality protein and micronutrients, which has contributed to long-term negative health outcomes, especially in women and children (Alders 2023).

Over the past decade the global demand for protein in the form of beef has grown. Although experiencing a slowdown compared to previous years, global meat consumption is projected to grow 0.75% annually between 2022 and 2025 (OECD/FAO 2021). It is forecast the growth in the Southeast Asian beef industry will continue from 2023 to 2032 due to low labour costs prompting global beef processors to move production to these regions; and increasing incomes leading to continued growth in consumption (Research and Markets 2022). In Southeast Asia the source of beef is primarily through cattle and buffalo. The cattle population can be further divided into local and exotic (introduced) breeds, with the latter often requiring additional feeding due to their increased size and nutritional requirements.

Fulfilling the increasing demand for protein requires improvements in production at a local level, as imports are expensive and tailored towards higher income customers and not the population in most need. To become more self-sufficient as well as access export opportunities, large-ruminant smallholder farmers need to change from being 'livestock keepers', where animals are kept primarily for draught and to store wealth, to becoming 'livestock producers' with production and income generation goals. This requires research for development in the areas of health, production and animal welfare.

Despite advances, many challenges still exist, with education and extension likely drivers to assist in further productivity improvements. In addition, challenges exist with disease management and eradication, training, climate variability, gender empowerment and policy in addition to major global factors such as the COVID-19 pandemic and associated implications, which continue to require consideration.

This review paper will provide an update on advances in smallholder large-ruminant production and profitability in Southeast Asia over the past decade, focusing on Cambodia and Laos within the Mekong region due to their high proportions of population living below the national poverty line, at 17.8% and 18.3% respectively (Asian Development Bank (ADB) 2023). In addition, ongoing challenges for smallholders will be highlighted that require further investment from governments and the private sector to meet the growing regional and global demand for protein that is safe for human consumption.

Advances over the past decade

Investment in activities to improve the health, production and welfare of smallholder large ruminants has been a feature throughout Southeast Asia over the past decade. Arguably, the two key areas to be addressed include nutrition and disease control due to their influence over smallholder household productivity and profitability.

Nutrition

Malnourishment through limited nutritional quality and quantity has implications for animal health, production and welfare, resulting in susceptibility to disease and underperformance (Harvatine 2023). Large ruminants are capable of converting roughages into utilisable nutrients, making use of introduced forages as well as rice straw and other byproducts that are indigestible to humans and would otherwise be wasted (Sarnklong *et al.* 2010; Honan *et al.* 2022).

1. Forages

The uptake of high yielding forages has been a major advancement in improving large-ruminant production in Southeast Asia over the past decade. Although forage-growing technology is not new (Stür and Horne 2001; Stür *et al.* 2002), the widespread uptake and utilisation is more recent and likely due to an increase in the demand and value for large ruminants as well as time savings for all members of the household, including women and children (Bush *et al.* 2014a; Ashley *et al.* 2016, 2018a). This is especially the case for areas where rainfall is limiting during the dry season and grazing of rice stubble and cut-and-carry of poor-quality roadside grasses are the only options (Horne *et al.* 2005). In addition, cattle and buffalo are restricted from free grazing in the wet season to prevent damage to growing crops (Devendra and Thomas 2002). The uptake of introduced forages can be more challenging in regions where free grazing of natural grasses maintains livestock weight and body condition without the associated costs and labour, such as in northern Laos (Phouyyavong *et al.* 2019).

The improvements in nutritional value associated with growing introduced forages are evident in productivity gains. Feeding introduced forages to cattle in Cambodia achieved weight gains of 0.19 kg/day over a 104-day period compared with traditional cut-and-carry feeding practices where animals lost on average 0.04 kg/day with forage-fed animals gaining, on average, 25.9 kg more weight than animals fed in a traditional manner (Bush *et al.* 2014b). Similar outcomes were achieved in Lao People's Democratic Republic (PDR), where cattle and buffalo in fattening stalls gained 0.32 and 0.22 kg/day respectively over a 4-month period, and 0.04 and 0.09 kg/day when free-grazing (Bush *et al.* 2014b). It is suggested greater weight gains are possible if farmers feed forages at the recommended 15% of bodyweight on a fresh-weight basis per day (Bush *et al.* 2014b).

In addition, the feeding of introduced forages grown close to the household results in time savings of up to 3 h per day (Dimang *et al.* 2009; Ashley *et al.* 2016, 2018a; Le Phi Khanh *et al.* 2020). These time savings enable children to spend more time at school and adult household members to seek off-farm income or spend more time conducting

household duties or socialising (Dimang *et al.* 2009; Ashley *et al.* 2016, 2018a; Le Phi Khanh *et al.* 2020).

2. Rice straw

Rice is readily grown throughout Southeast Asia to provide a base diet for the human population (Fukagawa and Ziska 2019). However, the intake of rice straw by ruminants is limited as although it is rich in polysaccharides, it has a high lignin and silica content, reducing degradability by ruminal microorganisms (Sarnklong *et al.* 2010). Treatments to improve voluntary intake of rice straw are physical or chemical. Physical treatments require machinery that can be expensive and prohibitive to smallholder farmers; whereas chemical treatments such as NaOH, NH₃ or urea are more accessible and practical for on-farm use (Sarnklong *et al.* 2010). Rice straw has delivered productivity gains in large ruminants with increases in crude protein content from 4.7% to 7.9% and the DM digestibility from 47% to 55% reported when treated with a urea–molasses solution (Aquino *et al.* 2020) and increases in ADG of 18.9–28.9% when treated and fed with byproducts (Aquino *et al.* 2020). Although the benefits are apparent, the sustainability of feeding rice straw is limited, likely due to the labour intensiveness of preparing the straw as well as the cost of machinery and chemical treatments such as urea (Aquino *et al.* 2020).

3. Crop byproducts, residues and supplements

Crop byproducts and residues are readily available and regularly fed to large ruminants throughout Southeast Asia. Large ruminants require energy and protein in their ration to stimulate rumen function and enhance productivity (Wanapat 2009). An example of a byproduct commonly fed to large ruminants is cassava roots fed as dry chips or pellets to provide energy and dried leaves (hay) for protein (Wanapat 2009). Hence, cassava provides a year-round feed source that can be used when seasonal conditions result in feed gaps. There are also other readily available byproducts in the tropics that can be used to feed large ruminants (Wanapat 2009) with the most common crop residues and agro-industrial byproducts being rice straw, cassava pulp and wet brewers' grains, providing a source of roughage, energy and protein sources, respectively (Napasirth and Napasirth 2018).

The use of lick blocks, with or without molasses, has demonstrated improved growth rates (measured as ADG) during the dry season when nutrition is limiting in young calves (251–265 g/day), growing calves (198–237 g/day) and lactating cows (187–190 g/day) (Windsor *et al.* 2021). Accompanying surveys confirmed farmers using blocks stated their animals were calmer and healthier and had better coat condition with minimal external parasites (Windsor *et al.* 2021). There is also evidence to suggest the use of high-quality molasses blocks will inhibit greenhouse gas (GHG) emissions (Windsor and Hill 2022) and control internal parasites when containing fenbendazole (Olmo *et al.* 2020).

Disease control

There are numerous livestock diseases impacting large-ruminant production throughout Southeast Asia that negatively impact productivity through mortality and morbidity as well as trade restrictions, particularly export opportunities. The most notable disease is Foot and Mouth Disease (FMD), with other zoonotic and production diseases also present. Control typically relies on vaccination, with biosecurity measures proving challenging due to widespread livestock transboundary trade and movement between villages, regions within a country and across national borders (Subharat *et al.* 2022).

1. Foot and Mouth Disease (FMD)

FMD is endemic throughout the region (Rweyemamu *et al.* 2008) and considered the most important transboundary animal disease (TAD), representing a failure of the global food security system (Rushton 2009) with the economic impact estimated to be USD6.5–21 billion per year in the endemic regions of the world (Knight-Jones and Rushton 2013). Seroprevalences for FMD (nonstructural protein) NSP in large ruminants, reported at 50.5% (95% CI: 49.0, 52.0), are high compared to Q fever and brucellosis; which are low at 1.7% (95% CI: 1.3, 2.1) and 0.7% (95% CI :0.5, 1.0) respectively (Siengsan-Lamont *et al.* 2022). Losses of annual household income due to FMD of 16–60% have been reported in northern Laos (Nampanya *et al.* 2015) and are likely similar throughout the region where FMD is endemic.

Several regional programmes were introduced to reduce the impacts of emerging infectious and transboundary animal diseases on food security, public health and livelihoods in Southeast Asia (Hampshire 2014). These include the Stop Transboundary Animal Diseases and Zoonoses (STANDZ) project from 2011 to 2016 and the Southeast Asia FMD (SEAFMD) campaign initiated in 1997 to facilitate a strategic and collective approach to FMD control in the region (MacPhillamy *et al.* 2021b). The SEAFMD programme expanded to become SEACFMD with the inclusion of China (Hampshire 2014). Aims of the programmes include strengthening national animal health and veterinary services, improving regional and international coordination for animal health, and supporting Office International des Epizooties (OIE)-led subregional activities (MacPhillamy *et al.* 2021b). Through the STANDZ and SEACFMD programmes, approximately 1.6 million doses of FMD vaccination were administered to large ruminants in northern Laos under the National Lao FMD Plan from 2013 to 2016, reducing the incidence of FMD outbreaks and increasing farmer incomes (Nampanya *et al.* 2018).

2. Other diseases

In addition to FMD, health and production diseases impacting large ruminants throughout the region have also been investigated. A key disease often mistaken for FMD is haemorrhagic septicaemia (HS), which is an acute

fatal infectious disease of mainly cattle and buffalo (Kawasaki *et al.* 2015). A study in Cambodia found 24% of all household large ruminants were affected with an estimated mean village herd morbidity of 10.1% and mortality of 28.8% (Kawasaki *et al.* 2015). Buffalo had higher morbidity and mortality compared with cattle, and unvaccinated large ruminants a higher morbidity. HS was found to cause substantial financial losses for smallholders and remains a critical constraint to improving large-ruminant productivity and profitability (Kawasaki *et al.* 2015).

Studies in Cambodia on pathogens causing reproductive losses in cattle and buffalo detected antibodies to *Neospora caninum*, bovine viral diarrhoea virus (BVDV), *Leptospira interrogans* serovar Hardjo and *Brucella abortus* in buffalo samples at 79.3% (95% CI 64.6–94.0), 3.4% (95% CI 0–10.0), 0% and 0%, respectively, and in cattle at 4.2% (95% CI 2.4–6.0), 6.4% (95% CI 4.2–8.6), 8.1% (95% CI 5.6–10.6) and 0%, respectively (Olmo *et al.* 2021). This provides important awareness of the presence of pathogens responsible for potentially compromising bovine fertility and creating a zoonotic risk for smallholders. In addition, information on the absence of pathogens provides incentives to implement strategies designed to prevent introduction. Large-ruminant reproductive management skills of smallholder farmers and parameters of reproductive efficiency in cattle and buffalo were studied in northern Laos (Matsumoto *et al.* 2017). The surveys included female farmers to provide gender-disaggregated data, with females making up 38.3% of participants (Matsumoto *et al.* 2017). Results confirmed low knowledge levels amongst smallholder farmers in relation to reproductive management of large ruminants (34–46%) and poor reproductive parameters were identified: with low calving percentages of 54–75 and 45–54% in cattle and buffalo groups respectively, and prolonged intercalving intervals of 14.1–19.8 and 26.0 months for the cattle and buffalo groups respectively (Matsumoto *et al.* 2017).

Internal parasites impacting large-ruminant productivity also have the potential to impact humans. An example is Fasciolosis, caused by *Fasciola hepatica* and *Fasciola gigantica*. The rapid detection requires species-specific assays for an antemortem diagnosis in both humans and animal. A new molecular workflow was developed in Laos to provide a sensitive and quantitative diagnostic approach for the rapid testing of medium to large sample sizes (Calvani *et al.* 2017). This approach provides a quicker alternative to the traditional sedimentation and faecal egg count (FEC) technique, enabling surveillance programmes in locations where animal and human health funding is limited (Calvani *et al.* 2017). Another study in Laos investigated the potential translocation of parasites from endemic to nonendemic areas, via associated international livestock movements (Calvani *et al.* 2020). The presence of *F. hepatica* DNA was confirmed through qualitative and quantitative sequencing (Calvani *et al.* 2020). From this

work a protocol was developed for the rapid detection of *Fasciola* species eggs, their coinfection and/or infection with *F. hepatica*/*F. gigantica* hybrids from faecal samples (Calvani *et al.* 2020).

3. Biosecurity

The concept of biosecurity is relatively new in countries such as Cambodia and Laos, where traditionally vaccination is the main approach to disease control. However, globalisation has resulted in an increased risk of disease transmission to livestock and humans through the worldwide trade in livestock and livestock products (Manuja *et al.* 2014). In addition, vaccine efficacy and a reliable cold chain for vaccine storage can be problematic. Examples of highly contagious diseases of livestock and poultry include FMD, peste des petits ruminants, African swine fever (ASF), Newcastle disease, avian influenza and zoonotic diseases caused by viruses like Nipah, Hendra and swine influenza (H1N1) (Manuja *et al.* 2014). Biosecurity measures are designed to prevent the introduction of disease through understanding the risks associated with the introduction of infections through livestock and livestock products as well as routes of transmission (Manuja *et al.* 2014).

A study in Cambodia demonstrated smallholder farmers adopted biosecurity practices, including a willingness to vaccinate for FMD and HS at their own cost, separate sick from healthy cattle, grow and feed forages and awareness of the benefits of building fattening pens (Young *et al.* 2014). Further, smallholder farmers that adopted these practices significantly increased annual household income (Young *et al.* 2014). In Cambodia it was demonstrated that positive biosecurity and disease reporting behaviours by village animal health workers (VAHWs) are correlated with high levels of knowledge (MacPhillamy *et al.* 2021a). This provides evidence that improved training of VAHWs, with regular monitoring and evaluation of training programmes, will likely further strengthen the livestock sector through improved disease surveillance and management (MacPhillamy *et al.* 2021a).

Diversification

Challenges around declining prices for traditional crops and irregular rainfall patterns has led to farmers diversifying income sources (Ashley *et al.* 2018b). Mixed livestock enterprises comprising pigs, poultry, small and large ruminants provide an approach to realise a regular income and spread the risk associated with disease and produce price. A study in Cambodia found household income from on-farm (51%) and off-farm (49%) sources were similar, with cattle raising the most common source of on-farm income (85%), contributing 22% of total household income (Ashley *et al.* 2018b). Rice (energy) and chicken meat (protein) were ranked as the most important for household food requirements. From this

study it was evident smallholder cattle-owning households undertake a diverse range of on-farm activities, with cattle generating most income due to higher returns and lower variable costs (Ashley *et al.* 2018b).

Smallholder farmer engagement

To gain farmer buy-in and uptake of strategies designed to improve large-ruminant productivity and profitability, it is essential to promote the benefits of specific interventions and gain trust through successful outcomes. For this to occur, an understanding of the current constraints and opportunities is required to determine appropriate strategies.

1. Forages and weigh tape

The benefits of forages to improve large-ruminant productivity and household livelihoods have been discussed in detail previously. An example of the success of forage growing was observed in Cambodia, where an initial establishment of 52 fodder plots covering 2.6 ha in 2008 expanded to 1306 plots covering 45 ha by 2011, including nonproject farmers from surrounding areas (Bush *et al.* 2014a). Although the establishment of forages did not have a significant effect on reducing the use of traditional feed sources such as rice straw, crop byproducts and crop residues, grazing of cattle on native pastures proved to be less common among adopter households (Ashley *et al.* 2016). Coupled with a significant reduction in daily time spent sourcing feed, average costs of fodder plot establishment of USD6.10 per 100 m² and the potential increased household income from forage establishment and forage feeding provided incentive for uptake (Ashley *et al.* 2016). To further enhance the benefits of improved nutrition from forage feeding for large-ruminant production and address a lack of farmer and trader knowledge of animal weights due to limited availability of liveweight scales, an accurate weigh tape was developed specific to cattle and buffalo to provide a cheap and easy tool to monitor animal production and health, and to assist in negotiating a fair sale value (Bush *et al.* 2014b).

2. Vaccination programmes

Demonstrating the successful use of vaccination for disease control has proven to be an effective farmer engagement tool (Young *et al.* 2014; Nampanya *et al.* 2018; Blacksell *et al.* 2019). However, it is important to note that success of vaccination programmes requires maintenance of cold chains, selection of the appropriate vaccines, correct vaccine administration, efficient vaccination programme strategies and sufficient quantities of vaccine (Blacksell *et al.* 2019). If any of these requirements are not met, the success of the programme is compromised, resulting in farmer distrust and a delay in vaccination uptake.

3. Lick blocks

Another engagement tool is the distribution of high-quality molasses lick blocks, which have demonstrated improvements in weight gain and parasite control in large ruminants in Laos (Windsor *et al.* 2019; Olmo *et al.* 2020). Blocks are easily fed out so require minimal labour, are suited to the tropical environment, and can have urea included to provide additional growth benefits, particularly in the dry season (Windsor *et al.* 2021). In addition, the blocks provide immediate benefits for the farmers through improved herd management, as animals were calmer and easier to muster, and had improved condition and coat, increasing saleability (Windsor *et al.* 2021). This successful engagement can then lead to promotion and uptake of other strategies such as forage growing and vaccination programmes.

4. Knowledge

Although monetary and material handouts are often eagerly sought by potential participants in research for development projects and associated training, the benefits are short-term and only last the length of the project. A longer-term and more sustainable approach is to promote knowledge as a beneficial commodity, where skills and understanding are obtained and utilised into the future. However, the topic of knowledge and how it interacts with intervention uptake or on-farm practice change is complex. It is well established that 'knowledge' or 'understanding' are not always enough for stakeholders to make changes in their own lives (or on their own farms). Other barriers to practice change include not fully understanding the benefits, concern about the time and costs involved and wanting to see successful implementation before committing (Ashley *et al.* 2018a). This requires all or a combination of the engagement approaches above to be implemented. In addition, identification of a 'champion' smallholder farmer who is respected by others and can visualise how the improvements will benefit their situation is required (Turner *et al.* 2021). This person will be an early adopter, with other farmers likely following and implementing the initiatives themselves.

Ongoing challenges and opportunities

Although much has been achieved in improving large-ruminant production and profitability there are still ongoing challenges to be addressed and opportunities to be embraced. Some general areas include disease management and eradication, training, adaptation to climate variability, gender empowerment and improved policy.

Disease management and eradication

The successful control of FMD has not been achievable despite many years of vaccination by individual countries. Potential

reasons include unregulated 'informal' transboundary movement of livestock and their products, difficulties implementing vaccination programmes, emergence of new virus topotypes and lineages, low-level technical capacity and biosecurity at national levels, limited farmer knowledge on FMD disease recognition, failure of timely outbreak reporting and response, and limitations in national and international FMD control programmes (Blacksell *et al.* 2019). A similar situation applies to other diseases where control requires a focus on improving smallholder farmer and VAHW knowledge of disease recognition, biosecurity and preventative vaccination (Kawasaki *et al.* 2015; Nampanya *et al.* 2018; MacPhillamy *et al.* 2021a, 2021b). In addition, without adequate resourcing of biosecurity measures, including national veterinary services that have the capacity to tailor specific disease-control responses, diseases will continue to persist in the region (Alders 2023).

Training

In all strategies covered in this review there is unanimous support by the researchers for ongoing training for all stakeholders from smallholder farmers including men, women and children through to government and nongovernment support agencies. A combination of ongoing intensive training and supportive interventions are required to improve large-ruminant reproductive outcomes in communities that have a low level of skill in large-ruminant husbandry (Matsumoto *et al.* 2017).

Climate variability

The need to increase food production without increasing the pressure on natural resources will require an increase in livestock productivity and not an increase in animal numbers (Turk 2016). However, climate variability is negatively impacting traditional ruminant grazing systems through elevated temperatures, more frequent and prolonged droughts, and erratic rainfall patterns, forcing producers to adapt different management practices (Turk 2016). Nutrition has been highlighted as a major limitation of large-ruminant production throughout Southeast Asia and will be further exacerbated with the impacts of climate variability. The increased likelihood of more intense and longer dry seasons places increased importance on appropriate strategies being implemented to provide large ruminants with their nutritional requirements for growth, development, reproduction and fattening. The benefits of forages and lick blocks have already been discussed in detail and appear appropriate for this challenge.

Gender empowerment

An area gaining increasing funding agency interest and allocation of resources is the role women have in large-ruminant production. Although women have been included

in training activities as part of research for development projects, their role in smallholder farming is still poorly understood. Learning more about what women think and their goals provides an opportunity to better understand and engage crucial members of farming households, who contribute to the farming system and local community.

Policy

The government of each country within the Association of Southeast Asian Nations (ASEAN) region has a priority of ensuring sufficient, affordable, and nutritious food for its growing population (Sundram 2023). This requires an integrated approach to address the impact of climate variability through investment in rural infrastructure and agricultural research, and the promotion of sustainable and inclusive agricultural practices to ensure long-term food security (Sundram 2023). To achieve this, policymakers, stakeholders and external partners will need to work collaboratively in order to leverage expertise and resources (Sundram 2023). This requires a focus on improving the productivity of existing large-ruminant resources instead of increasing numbers, which is unsustainable given the current environmental constraints that will likely persist or deteriorate due to climate change. The COVID-19 pandemic exposed the fragility of ASEAN food systems, exacerbating existing challenges and vulnerabilities (Sundram 2023), highlighted the impact of zoonotic disease and consumed huge portions of national budgets, removing available resources away from the control of diseases in livestock and other areas (Alders 2023).

Conclusions

Advancements in improving smallholder large-ruminant production, health and welfare in Southeast Asia have been made over the past decade. This includes the introduction of strategies to improve productivity and sustainability. Increasing global demand for protein in the form of red meat places smallholder large-ruminant producers in an ideal position to capitalise through the supply of product if they can address ongoing challenges. This requires ongoing investment in stakeholder training and adoption of appropriate strategies. If achieved, the result will be improved regional food security.

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