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REGULAR ARTICLES

The potential of small ruminant farming as a means of poverty alleviation in rural southern India

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Abstract

Small ruminant production has the potential to address the global challenge of greatly increased food production in impoverished rural areas in a manner that is socioeconomically sustainable and carbon efficient. Twenty-six small ruminant landless farmers in three villages in the Kanchipuram District of the state of Tamil Nadu were surveyed with regard to their sheep farming practice and production indices, with the preliminary aim of evaluating the potential of small ruminant farming in alleviating poverty in parts of rural in southern India. The small ruminant farmers reared mostly indigenous Madras Red sheep as a means of generating primary or supplementary income. Participatory interviews were undertaken to enable the completion of a questionnaire pertaining to sheep production over the four most recent annual production cycles (referred to as instances) at the time of the study. When calculating the annual farm profits without taking into consideration the opportunity cost of labour, 83% of annual sheep production cycles over a 4-year period added to household incomes. Further, 23% of the instances that accounted for the opportunity cost of labour, household income was raised above the Indian Government's defined poverty line solely through small ruminant farming. Management practices were identified, while participating in landless farmer interviews provided an insight into the husbandry, or lack thereof, which resulted in low lambing percentages and rates of high ewe losses, perinatal lamb mortality and abortion. The study showed both the vulnerability and potential resilience of small ruminant farming to natural disaster, in this case catastrophic flooding in 2015. While small ruminant farming generated income in most instances, the way it is practiced creates opportunities for simple changes in husbandry and management that could make it more efficient in poverty alleviation.

Keywords Sheep · Poverty alleviation · Opportunity cost of labour · Husbandry and health management · Natural disaster

Introduction

There is a growing population of landless farmers in southern Indian state of Tamil Nadu (TN), who use small ruminants as a means of generating of income. They experience disparities in production and income similar to their counterparts in other emerging countries in the region, which may be attributed to management of disease, feeding and husbandry (Wong and Sargison 2018). Despite this, small ruminants have played a role in providing income and dietary protein to poor, small-scale producers and their families (Iniguez 2011). Indigenous Madras Red sheep, the predominant breed reared by the landless farmers included in this study, is efficient converter of underutilised, poor-quality herbage and crop residues into meat and hides (Sivakumar et al. 2006; Soundararajan and Sivakumar 2011; Ganesan et al. 2014, 2015). Global markets for small ruminant products have expanded due to a growing urbanised human population, creating opportunities for landless producers in emerging agricultural economies (Kosgey et al. 2008).

From a quantitative viewpoint, poverty in rural India is defined as per capita consumption of less than Indian rupees of (INR) 32.16 per day or INR 965 per month (Spread Law 2011;

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Planning Commission Deputy Chairman's press note 2011). Since the TN average household consists of three and a half persons (Mari Bhat et al. 2007), this translates to an annual household consumption level of approximately INR 40,880 (Government for India Planning Commission 2012). Our study assessed and quantified landless farmers' profits and losses against these figures.

The aim of this study was to undertake a preliminary evaluation of the efficacy of small ruminant farming as a means of alleviating poverty through income generation in landless households in part of the Kanchipuram District, TN.

Materials and methods

Resources and data collection

Twenty-six landless farmers from three villages (Melkadirpoor, Vishar and Kilkadirpoor) of the Kanchipuram District were selected (based on their presence and willingness to participate when visiting their villages for the purpose of our study) from an estimated 50 small ruminant keepers (based on unofficial census information) in the study area. Participatory interviews with the landless sheep farmers were conducted over a 3-week period in August 2016 to provide objective information concerning sheep flock structures, production parameters, reproductive management, nutrition, health and disease management and production economics, and subjective information about their attitudes towards small ruminant production. A framework for the questions was set out in a questionnaire (Appendix 1), which was translated into the local Tamil language.

Expenditure and returns over a 4-year period

The cost effectiveness of small ruminant farming was determined using expenditure and returns to calculate annual flock profits. Expenditure included the opportunity cost of labour, defined in this case as the loss of potential gain from undertaking other activities, had not been necessary to tend the sheep. A full annual production cycle was considered to correspond for a year from the month of October, since the objective was for most ewes to lamb annually, and the majority of lambs were born in the period between October and March and sold within 6 months. Each of the four cycles in the period from the beginning of October 2012 to the end of September 2016 (subsequently referred to as 2013 to 2016) was treated as an independent instance that could have led to poverty alleviation or not. Surveying 26 farmers concerning the 4-year period gave rise to 103 instances (one started farming in 2013, hence the first full annual production cycle year was in 2014).

The purchase cost of the animals was allocated as an expense in the year of the instance. Any economic losses made were carried over to the following year to allow profitability to be evaluated over a 4-year period. Sample values for expenditure on vaccinations, deworming, other medicines and mineral supplements were used to compute the maintenance cost per animal. Daily grazing times and any other husbandry tasks were used to calculate labour inputs, the opportunity cost of which was calculated based on the highest government specified minimum wage rate in TN for unskilled labour of INR 325 (Government of India Ministry of Health and Family Welfare 2007), rounded up to INR 400. Opportunity costs of land and capital were not included, as there was minimal use of equipment and infrastructure. For example, common grazing was the only means of feeding, and makeshift pens made from brushwood comprised only for animal housing.

All of the farmers interviewed had prior experience in small ruminant husbandry, and all but one when interviewed had pre-existing herds, with some having farmed continuously for decades. This meant that the initial herd acquisition cost for 25 of the 26 flocks had already been defrayed over many years. Hence, only those costs associated with new introduction of animals were included in our calculations of profitability over the 4-year period.

Farm income was calculated as the number of animals sold multiplied by the average sale price. A farm was deemed to be profitable in a year if the income exceeded the expenses.

Use of key variables to model profitability

The values for key variables such as lamb birth and loss rates were specific to each farm. To further investigate the viability of small ruminant farming, we modelled farm profitability using median values for the key variables such as numbers for ewes and rams purchased in the first year of operations. Values for births, abortions, losses and sales were then used to project growth in the herd size, expenses and income from sale of animals. More specifically, expenses in the initial year were calculated as the purchase cost of the animals, herd maintenance costs and the opportunity cost of labour. In subsequent years, costs included any uncovered expenses (losses) from previous years. For these models, the purchase cost of the animals was expensed in the year of acquisition due to a lack of unambiguous data on longevity.

Calculation of production indices

Production indices were calculated using the data, and box plots were made using Microsoft Excel software to show relevant results.

Approvals and permissions

Ethical approval was gained from the University of Edinburgh Veterinary Ethics in Research Committee. Permission to work

with the sheep farmers in the Kanchipuram District was given by the Madras Veterinary College.

Results

Descriptive data

The 26 landless farmers each kept a median of 69 (range 22–216) sheep, with median numbers of 65 ewes, 9 lambs and 2 rams. Information about average herd sizes, reproductive management and performance indices, lamb sales and mortality rates for each of the 103 instances is shown in Appendix 2. All of the interviewed farmers owned their land, which consisted of their homes and nearby makeshift areas for their livestock, while grazing land was communal and government owned, thus rendering these fixed costs near zero. Labour was manual and co-workers were generally family members. Variable costs were the cost of rams, which were replaced every 5 years on average, and in newer flocks, the cost of the initial stock of ewes. Breeding ewe replacements were homebred. Supplementary feed was not provided and no consistent preventive medicine, such as vaccinations, worming or vitamin and mineral supplementation was implemented. These were the common practices seen amongst all of the farmers interviewed.

Expenditure and returns over a 4-year period

Comparison of variable costs, including the opportunity cost of labour and miscellaneous expenses, against the returns received from the sale of lambs, old ewes and rams showed that 58 of 103 (56%) of the instances over a 4-year period across the 26 farmers surveyed made a profit and thus added to household income. Twenty-four (23%) of these instances, sheep farming alone would have raised the household income above the Indian Government's defined poverty line of consumption of approximately INR 40,880 per annum (Fig. 1). These calculations imputed an opportunity cost of labour, as per the Indian Government's specified minimum wage for unskilled labour; but in reality, much of the labour used for the care of the animals was children under the legal working age, or the elderly, who would normally not be able to participate in the mainstream economy. Without taking into consideration, this opportunity cost of labour, 85 of 103 (83%) of the instances showed a profit over the 4-year survey period, while 39 (38%) had income greater than the poverty line of consumption.

In 79 of 103 instances where small ruminant farming was not successful as a sole means of providing household income above the poverty line of INR 40,880 annually, approximately 70% of the farmers had alternate means of income, while herding of the sheep was the responsibility of those otherwise unemployable due to age or impairment. Including (and excluding) the opportunity cost of labour, 11 (21) of 26, 7 (14) of 26, 20 (25) of 26 and 20 (25) of 25 sheep flocks generated a profit in the production cycle years of 2016, 2015, 2014 and 2013, respectively (Fig. 2a, b). Excluding the opportunity cost of labour, only the flock that was established in 2014 was loss making. Over the entire study period, including (and excluding) the opportunity cost of labour, 15 (25) of 26 sheep flocks generated a profit. Excluding the opportunity cost of labour, only the flock that was established in 2014 was loss making (Fig. 2c, d).

On November and December 2015 the Kanchipuram District was devastatingly affected by flooding. The Indian Government declared the surrounding areas as a National Disaster Zone (https://en.wikipedia.org/wiki/2015_South_Indian_floods accessed 29th April 2018). During these floods, there were unprecedented losses of livestock and infrastructure. Lamb birth rates reported by the landless farmers in our study were the lowest, and abortion rates, ewe deaths and lamb deaths were the highest during 2015 of any production cycle year in our study. Including the opportunity cost of labour in the profit calculations, 35 of the 45 loss-making instances were in the production cycle years of 2015 and 2016,

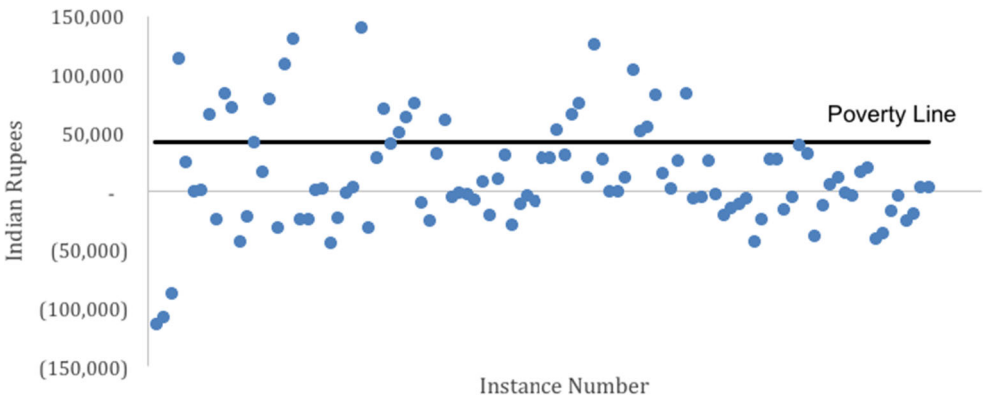
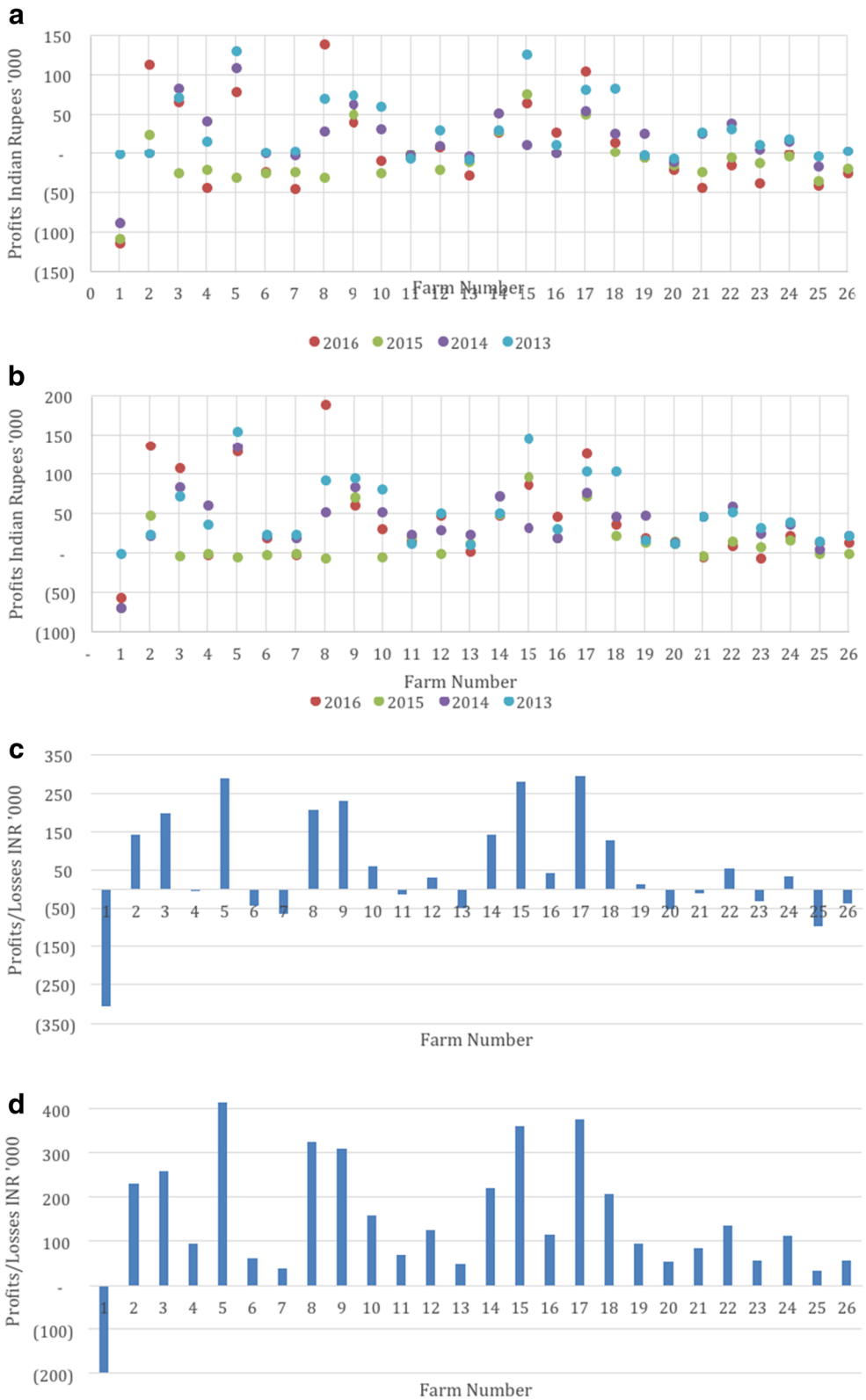


Fig. 1 Addition to annual household income between 2013 and 2016 by 26 sheep farmers. Fifty-eight of 103 (56%) instances over a 4-year study period made a profit as seen by the data points above the x-axis. Small ruminant farming raised household income above the poverty line in 24 (23%) instances



during and 1 year after the period when the flooding occurred. Excluding the opportunity cost of labour in the profit calculations (Fig. 3), 17 of the 18 loss-making instances were during the same period.

Modelling of profitability

The data that were used to construct median value and best case assumption models of farm income and expenses are

◀ **Fig. 2** Profits by farm and production cycle year, including (**a**) and excluding (**b**) the opportunity cost of labour. Farm profits and losses over a 4-year study period including (**c**) and excluding (**d**) the opportunity cost of labour. Farm profit calculations: *farm profits* = farm income − farm expenses; *farm income* = proceeds from sale of lambs, ewes and rams; *lamb sale proceeds* = number of lambs sold × lamb sale price; *ewe sale proceeds* = number of ewes sold × ewe sale price; *ram sale proceeds* = number of rams sold × ram sale price; *farm expenses* = purchase of rams + purchase of ewes + purchase of lambs + annual maintenance cost of herd + opportunity cost of labour + previous year losses; *purchase of rams* = number of rams purchased × ram purchase cost; *purchase of ewes* = number of ewes purchased × ewe purchase cost; *purchase of lambs* = number of lambs purchased × lamb purchase cost; *annual maintenance cost of herd* = (opening herd count + closing herd count)/2 x annual spend/animal; *opportunity cost of labour* = manpower cost per hour × (daily time spent per herd + (365/deworming and vaccination cycle length in days) × average time spent per animal); *previous year losses* = previous year expenses − previous year income (if previous year expenses > previous year income)

shown in Appendix 3. Given the linear nature of the projections, once profitable, the farm is able to cover additional purchase requirements such as those for ram replacement; hence, profits need not be held back for further investments. Thus, in the median values modelled, initial purchase costs in the first year and carried over losses in the next few, far outstrip income. However, as the herd size grows and more animals are sold, farm income increases and as progressively large parts of the initial losses are squared-off, expenses drop until a break-even point is reached in about the fifth year of operations. Subsequently, income continues to rise, however expenses settle down to maintenance and ram replacement costs.

The economic break-even time, using the median values of 65 ewes and 2 rams in the starting flock (hence including the purchasing cost of the 67 sheep) were modelled as being between 5 and 6 years, after which expenses stagnate and income continues to increase until ram purchases are made (ewes are homebred) (Fig. 4a). The hypothetical best-case scenario for sheep farming income and expenses was computed using the best values observed across all samples (Fig. 4b). In this model, the landless farmers could break even within the first year of starting small ruminant farming with a flock size of 262 ewes and the best observed values for birth rates, lamb losses, ewe losses and selling prices. Although unrealistic, this model illustrates the potential to improve farm returns by good husbandry and management.

While interest costs or the opportunity cost of capital would have been pertinent to the study, deeper financial analysis including differential amortisation curves, alternative capital and funding sources such as the prevalent 'share-raising' was beyond the scope of this study. It is pertinent in this regard to note that loans for animal husbandry in India, especially for marginal farming, are available for terms varying from 1 to 3 years at concessional rates. The low initial start-up cost of INR 210,000 (~£2300) for a herd of 70 ewes and subsequent replenishment of the ewes internally meant that while the farm may turn profitable later, it did not change profitability dynamics substantially if interest costs were considered.

Production indices

All of the data were based on recollection, and not on written records. The abortion rates, lamb birth rates per ewe, lamb death rates and ewe death rates during each of the four production cycle years are shown as box plots in Fig. 5a–d, respectively. The abortion rates are all higher than those that are seen in well-nourished flocks in the absence of infectious diseases. The birth rates are extremely low, given the potential for each ewe to give birth annually to twin lambs. The lamb mortality rates are mostly high and are cause for concern. The ewe death rates are notably low, with the exception of 2015. The plots show the impact of the floods on each of the production indices during the 2015 production cycle year and the consequential effect on low lamb birth rates during the following year.

Information gathered from the participatory interviews is pertinent to consideration of solutions to the problems underlying the poor production shown in Fig. 5. Lambs were separated from the ewes at birth and fed formula or cows' milk

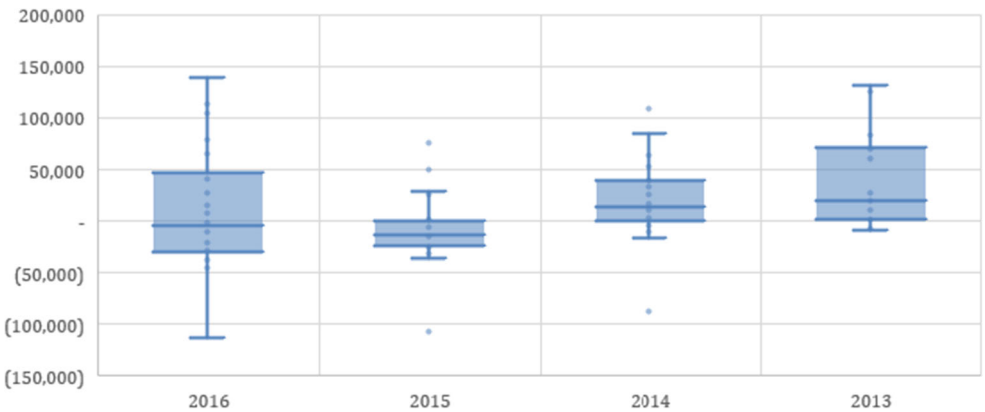


Fig. 3 Farm profits by production cycle year, excluding the opportunity cost of labour (Indian rupees)

instead of colostrum so that the ewes could graze. Navel dipping in strong iodine for the prevention of infections was not undertaken. The 26 farmers interviewed described their lambing season as being all year round. Ewes and rams were not separated throughout the year and most landless farmers used homebred rams, resulting in uncontrolled mating and a high risk of inbreeding. Seven of the 26 study of the landless farmers discussed hoping to improve lamb carcase weights through the introduction of rams of the larger Nellore breed, native to Andhra Pradesh.

Discussion

Analysis and presentation of the results of our study was based on information given by the landless farmers. In India, there is an abundance of superstitions and negative propaganda about disclosing of information, which may have given rise to discrepancies in some instances. Additionally, there is no routine practice of recording data; hence, the information that we provided was based solely on the farmers' recollection. The framework for our interviews set out in the questionnaire and responses were translated between Tamil and English, which could have resulted in misunderstandings and biases. The unofficial census that estimated 50 small ruminant keepers in the study region may have been unreliable; hence, the farmer sample size might not have been representative of the regional population. Equally, all of the data used in the study were primary, and the credibility of information was supported by the participatory manner in which it was collected, involving our visiting and observing the landless farmers as they engaged with their sheep flock routines.

Economic analyses of our data show that small ruminant farming has the potential to generate income, and if undertaken efficiently can raise household incomes above the poverty line. This is possible because grazing throughout the year on the Indian Government owned land is free, and supplementary feeding is not required. This situation is only sustainable when there is no opportunity costs associated with the free grazing land, for example where its alternative use for cattle or buffalo grazing, or growing cereal crops, or vegetables is not economically or

Fig. 5 Abortion rates (**a**), birth rates (**b**), lamb death rates (**c**) and ewe death rates (**d**). In the box plots, the range between the upper and lower whisker indicates the range of the data set. Points outside the whiskers are considered outliers and not included in the distribution calculations. The range between the lower whisker and the start of the shaded box gives the first quartile of the data. That between the upper end of the shaded box and the upper whisker gives the fourth quartile. The shaded box itself represents the interquartile range between the upper and lower quartiles, that is quartiles two and three. The line inside the shaded box represents the median value representing the centre of the distribution with 50% of the values lying on either side of it

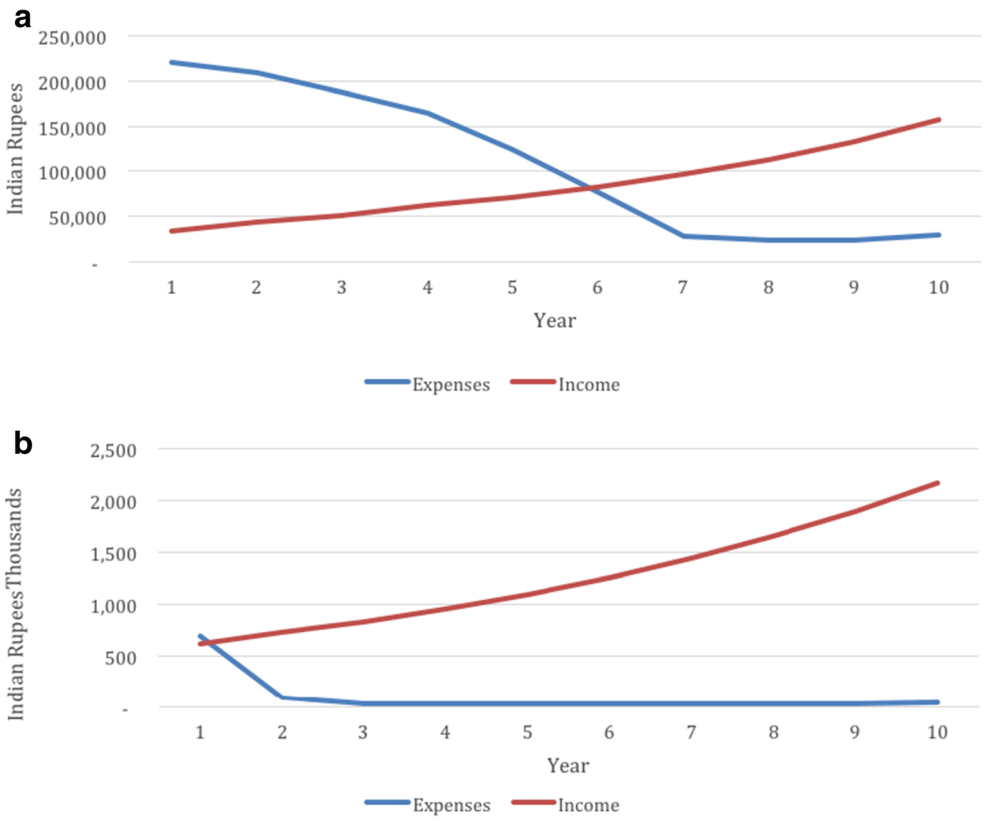
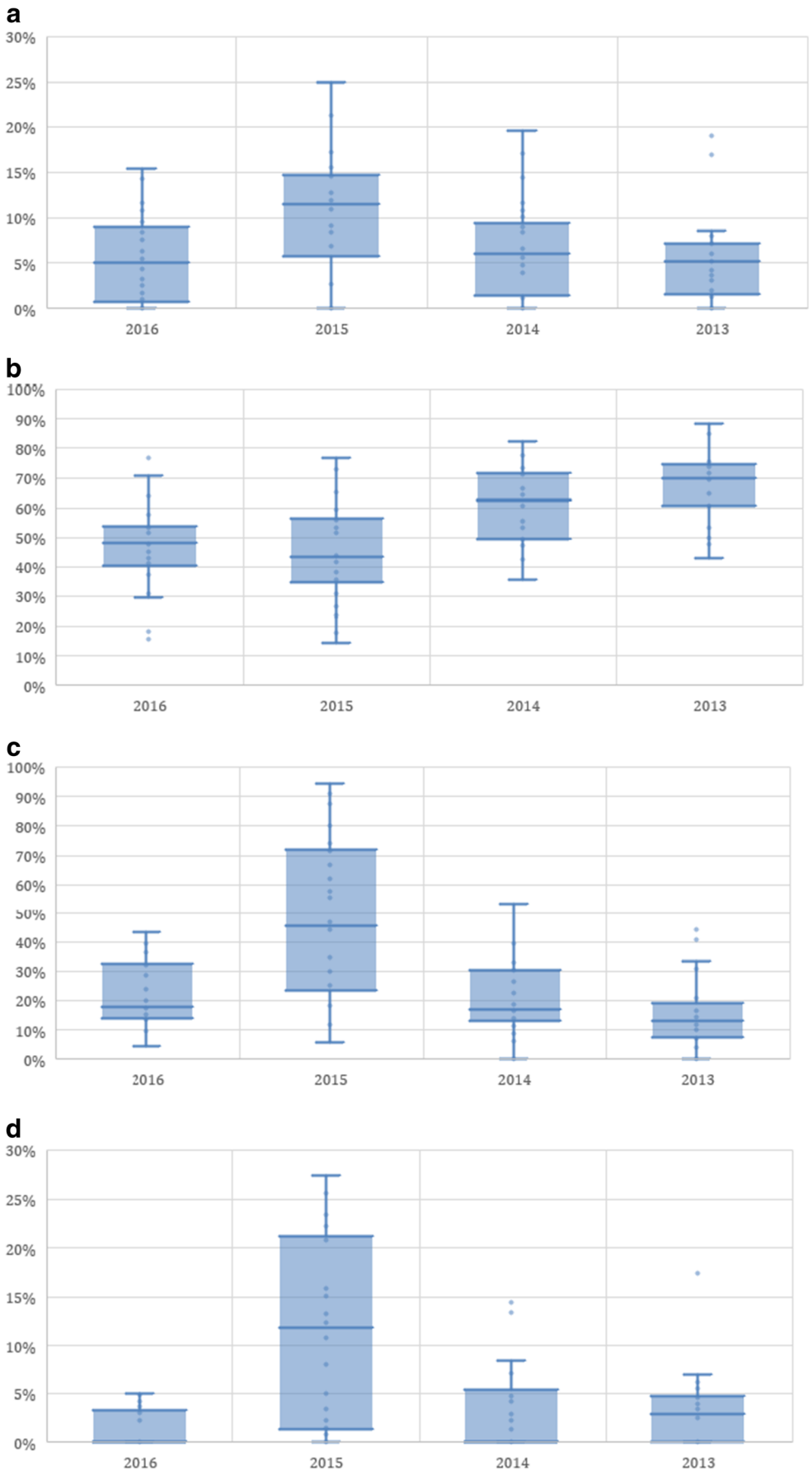


Fig. 4 Median value assumptions for modelled farm income and expenses (**a**). Best-case assumption model for sheep farm income and expenses (**b**). The models are based on the data shown in Appendix 3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environmentally sustainable. In this regard, small ruminants are suited for enhancing the health and wellbeing of the world's rural poor, who live mostly in marginal sub-tropical environments such as the Kanchipuram District, due to the efficiency with which they can convert poor quality herbage into meat and skins (Pollott and Wilson 2009). These principles underpin the TN Government's so-called four-goat scheme, whereby landless women workers are provided with animals to exploit free grazing, generate income and enhance their social status.

When the opportunity cost of labour was removed from our calculations, 25 of the 26 sheep flocks generated a net profit over a 4-year study period, further demonstrating the potential of small ruminant farming in poverty alleviation. This observation is only supported from a socioeconomic perspective, where there is a lack of alternative adequate employment or where most of the labour, typically women and children, would normally not be able to participate in the mainstream economy, with the proviso that the work tending small ruminants is not exploitative.

Our study identifies scope for improved reproductive management in accordance with a previous report showing better liveweight gains of Madras Red lambs following more precise management of their dams during a relatively compact mating period, compared to those born following an unmanaged mating period (Devandran et al. 2009). Each of the 26 landless farmers interviewed in our study described their lambing season as being all year round, albeit predominantly between October and March, corresponding with relatively cooler and humid weather and best herbage growth, while avoiding the peak monsoon period between June and September. Depending on flexibility of market value chains, there is a scope to improve the productivity of their flocks by timing the mating and lambing periods more precisely to match the seasonal availability and quality of natural herbage, as proposed for Malabari goat production in southern Indian state of Kerala (Sargison et al. 2017). The management of each of the flocks in our study involving the use of homebred rams kept alongside ewes throughout the year would have resulted in inbreeding. This is a common problem in landless farming systems, which can be overcome, for example, by communal grazing management allowing rams to be herded separately and shared between flocks when required (Jaitner et al. 2001). This may prove to be more effective in reducing inbreeding in our study population than the periodic purchase of new rams and consideration of breed substitution that is currently put into practice or considered.

Ovine abortion is evident, hence was reported during our participatory interviews. Nevertheless, the high incidence, along with concern that many causes of ovine abortion are zoonotic, shows a priority for diagnostic protocols and preventive management. Our survey shows that the way in which lambs may be deprived of adequate colostrum while their dams are taken to grazing may contribute towards poor neonatal survival. This challenge is common wherever livestock must be taken to free grazing during the day (Leahy et al. 2017).

Our study shows the intelligence and agribusiness acumen of TN small ruminant landless farmers and implies a willingness to improve the production efficiency and profitability of their sheep flocks. The management practices and production indices identified when interviewing farmers in the Kanchipuram District provide a pragmatic starting point for engagement in planned animal health management and education to improve the productivity of their sheep flocks (Sargison 2017). Experience from developed agricultural economies shows that engagement based on addressing perceived animal health challenges, for example abortion, allows for the development of strategies aimed at the management of problems that may be less apparent, but greater in their impact, for example parasitic helminthiases (Soundararajan 2014).

Most instances where sheep farming failed to yield profit were during the year of October 2015 to September 2016, corresponding the period when Kanchipuram was declared a National Disaster Zone, and in which sheep production indices were poorest. Our study, therefore, shows the impact of natural disaster, both at the time of the severe flooding events, which prevented access to grazing, and in the following year as a consequence of losses of breeding animals and poor condition of survivors. We also show the resilience of small ruminant farming to survive one-off disastrous events due to the low-maintenance requirements, low-capital investment cost and their short generation interval when compared to cattle and buffalo (Singh and Ramkumar 2014).

Global poverty is most apparent in rural regions where people depend upon agriculture for subsistence; hence, improved livestock production efficiency provides an obvious route towards improving the health and wellbeing of the rural poor living in marginal environments that present seasonally favourable conditions for agriculture. In summary, our results support the contention that sheep farming has the potential to alleviate poverty in southern India, while being resilient to short-term challenges such as severe flooding. We have identified scope to improve the profitability of sheep farming by addressing failures to meet pragmatic production targets that are commensurate with the animals' genetic potential through basic husbandry and health management.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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