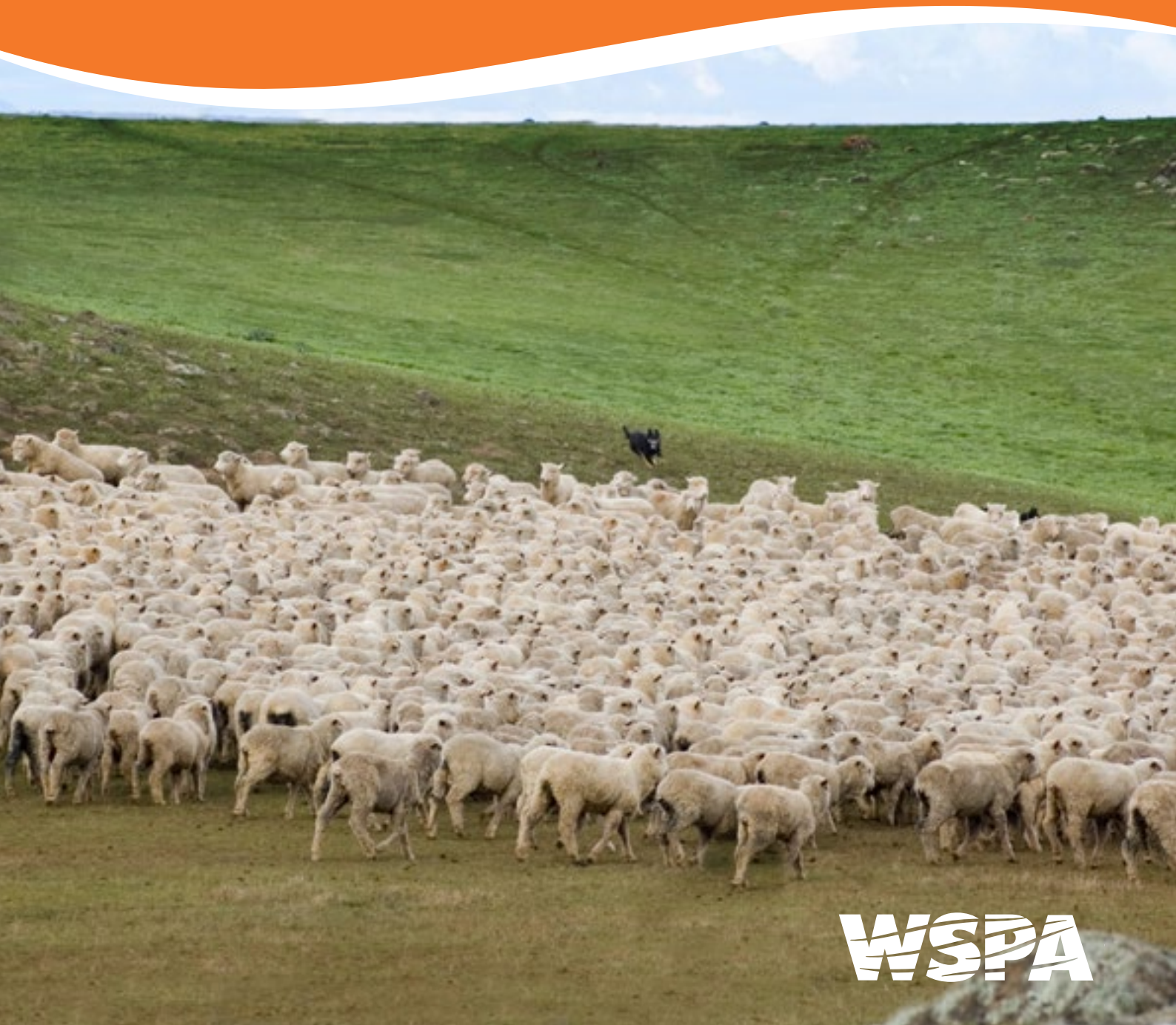
World Society for the Protection of Animals

The case for preparedness: Quantification of production losses due to livestock deaths from disasters in Australia

Paper by Emma Coll for the World Society for the Protection of Animals, February 2013



Introduction

When faced with imminent danger from disasters, farmers have ethical and financial drivers to minimize the potential impacts to their livestock. Ethically, farmers have welfare considerations to ensure their livestock do not suffer avoidable distress from injuries, hunger or a slow and painful death as a result of disasters. From a financial standpoint, farmers have invested time and money into the health and growth of their livestock. Premature death due to disasters will result in this time and money being wasted, as the full economic potential of their livestock cannot be realized.

Despite the ethical and financial incentives for farmers to minimise any impacts of disasters on their livestock, the frequency and magnitude of livestock losses to disasters in Australia means that farmers can never fully eliminate the risks of exposure of their livestock to hazards in the natural environment. All land has the potential to be subject to threats or events that can turn into disasters.

Despite a good understanding of the hazards faced by Australian farmers, there is evidence of a gap between knowledge and action in terms of livestock-oriented disaster preparation activities and appropriate levels of insurance to cover livestock losses to disasters.

At a state government level, there is increasing recognition of the importance of considering livestock in disaster planning. In response to the Royal Commission into the 2009 Victoria bushfires, the Victorian Emergency Animal Welfare Plan was developed, drawing in representatives from State government, Australian Veterinary Association and the RSPCA (White, 2012).

This paper attempts to directly quantify the costs of losing livestock to disasters in order to present a comparison between the potential economic costs and the cost of livestock-oriented disaster planning.

Structure of this report

This report is broken into four sections. The first provides some background about what is included in this report, as well as briefly outlining the methodology used to estimate the impact of livestock losses on the economy. The second section considers the importance of agriculture to the Australian economy as well as natural hazards faced in Australia. The third section applies the evaluation model to disasters that have occurred in Australia. The final section discusses livestock-oriented disaster planning specific to bushfires and flooding.

1. Background and Methodology

What this report covers

The losses modelled below represent the gross output lost to the agriculture industry based on the loss of livestock to disasters.

This report focuses on the impact of livestock losses in order to inform discussions and investigation of the potential savings to the economy of evacuation or protection of livestock in times of disaster.

The gross output per animal is calculated based on June 2011 figures, and is based on disasters that have occurred in Australia in the past 50 years. The use of 2011 figures essentially illustrates what the loss in gross output would be if the disaster had occurred in 2011.

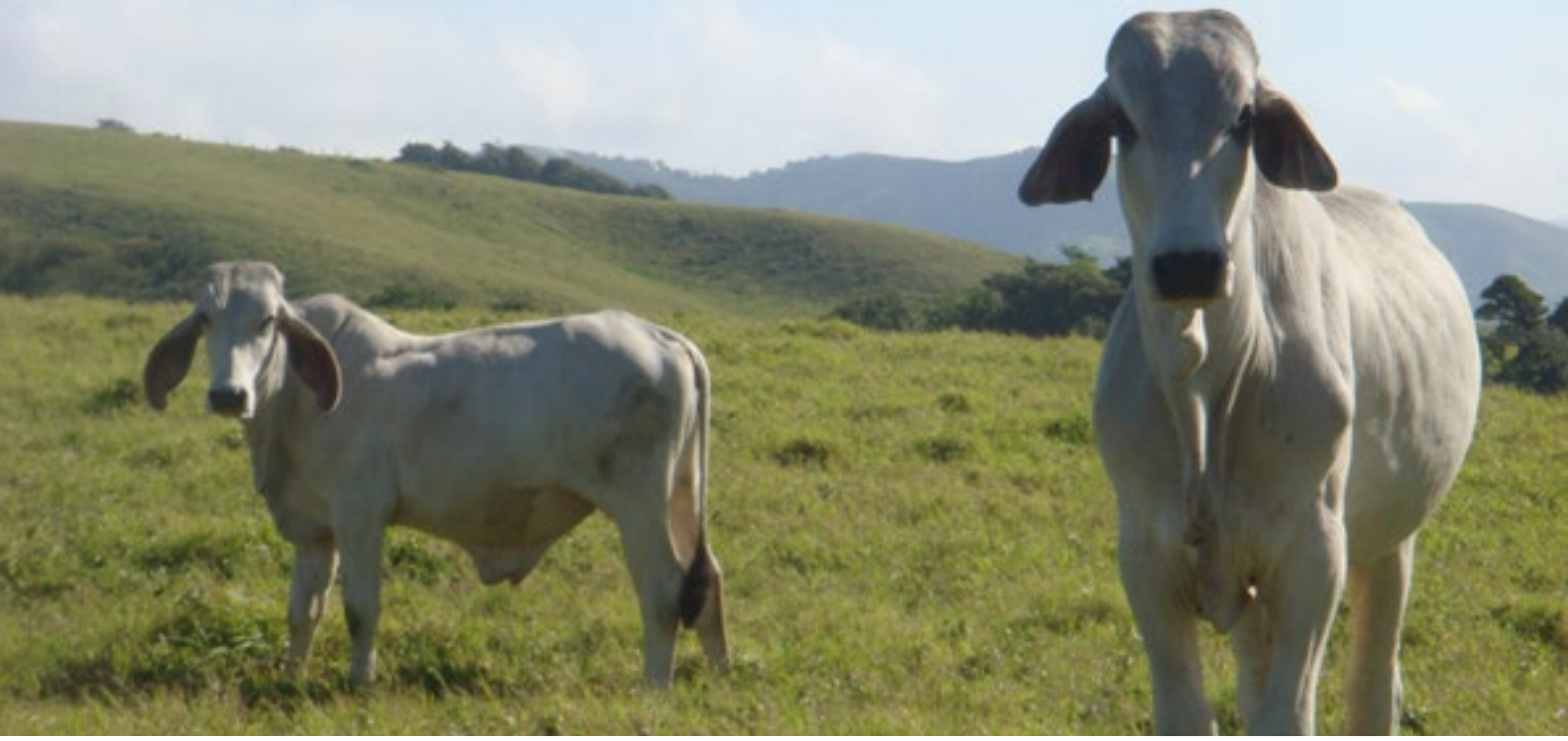
What this report does not cover

While not covered in this report, the logical progression of this work is to complete a study of the costs of livestock-oriented disaster preparation activities, in order to present a cost-benefit analysis comparing the likelihood and cost of livestock losses to the costs of preparation activities.

The economic model that forms the basis of this report does not include other significant economic impacts such as;

- damage to capital assets
- damage to other farm infrastructure such as electricity, fences and machinery
- production losses due to interruptions to transport soil erosion and silting
- crop losses

While the costs to the Australian economy and to farmers directly from the damages listed above



are substantial, they have not been evaluated in the cost model that supports this report. This is not an accidental omission. The modeling underpinning this report focusses on the costs that can be avoided through livestock-oriented preparation activities in order to consider the costs of these activities against the reduction in potential losses. Costs related to impacts such as damage to capital assets and crop losses are unlikely to be reduced by livestock-oriented preparation activities, and as such they have not been considered in the modeling.

Some benefits of livestock-oriented preparation activities are less quantifiable, for instance the reduction in suffering of livestock as a result of disasters and the emotional impact on farmers witnessing large scale losses of their livestock. Owner responsibility for the welfare of livestock in the time of disasters is not debated in this report. This work hypothesises that the economic benefits of livestock-oriented preparation and response activities compared to the costs of these actions will be of sufficient magnitude that further evidence of the less-quantifiable benefits will not be necessary.

Likewise, the psychological and social impacts of disasters on rural communities are not measured in this report.

Definitions

Livestock
For the purposes of the modeling that underpins this report, livestock are determined by animals included in the Australian Bureau of Statistics (ABS) coverage in their valuation of gross domestic product (GDP). This includes cattle, sheep, poultry, pigs, goats and horses farmed for commercial purposes.

While other farmed animals, such as alpaca and deer, are included in GDP calculations, the gross value of their production is not reported at a species level. Thus, they are not able to be modelled in this report.

Loss
When referring to the 'loss' of livestock in this report, it is meant that the animal has either died as a direct result of a disaster, or is euthanized as a result of the disaster.

Disasters
The Australian Emergency Management Institute defines disasters in the National Strategy for Disaster Resilience (2011) as:

A serious disruption to community life which threatens or causes death or injury in that community and/or damage to property which is beyond the day-to-day capacity of the prescribed statutory authorities and which requires special mobilisation and organisation of resources other than those normally available to those authorities.

The events used for modeling in this report incorporate aspects of this definition, in that they:

- cause serious disruption to rural community life
- involve damage to agricultural property
- are of such a scale as to overwhelm not only

the capacity of farmers, but also of statutory authorities.

Another commonality of the disasters in this report is that they all have a quite rapid onset. In reality not all disasters are rapid onset – drought and the spread of HIV-Aids are examples of slow-onset disasters. However, as will be discussed later, this modelling focuses on rapid onset disasters.

Further, many of the events discussed below were not unforeseen. While the full extent or exact location of damages may not have been predicted, Australia has well developed forecasting, monitoring and communication mechanisms for weather events and fire danger.

Natural and anthropogenic disasters are not differentiated in this report, reflecting that the focus of the outputs is on the impacts, not causes of disaster.

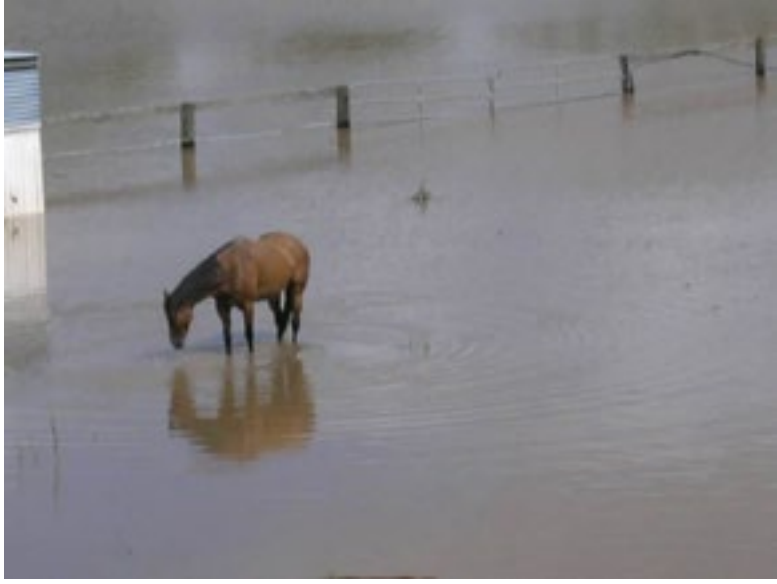
Methodology

Methodology – estimating livestock losses
Data sources for identifying numbers of livestock lost in disasters include:

- Australia Emergency Management Knowledge Hub
- Australian Bureau of Statistics (ABS)
- Australian Bureau of Meteorology
- Department of Primary Industries, Victoria
- Department of Primary Industries, New South Wales
- Department of Agriculture and Food, Western Australia
- Federal Department of Sustainability, Environment, Water, Population and Communities
- Academic journals

As reports of losses of cattle are not generally separated between dairy and non-dairy cattle, where necessary total losses have been proportioned based on the ratio of dairy to non-dairy cattle in Australia for that year.

The disasters used in this report were selected because they had the most reliable data available on livestock losses.



Data sources for valuation of livestock
Annual constant price output of agriculture as a component of Gross Domestic Product (GDP) is calculated by the ABS using quantity revaluation. That is, livestock production is measured based on the sum of sales and the change in inventories year on year.

Gross output of livestock production and dairy farming can be modelled using June 2011 figures released by the ABS of:

- Agriculture output for wool, sheep, cattle, pigs, poultry and dairy products
- Value of change in inventories
- Total slaughter numbers by animal type
- Total milk production
- Egg production
- Wool receipts

The gross value of livestock farmed for meat is calculated using the total value of output for the species, plus any change in the value of inventories at the end of the year. The value per animal is calculated by dividing the total value for the species by the number of animals slaughtered in that year.

Similar calculations are used for producing livestock, such as dairy cows or sheep for wool. For example the output of dairy cows is estimated by dividing the total value of dairy outputs for the June 2011 year by the number of dairy cows in Australia at June 2011.

Output per animal for dairy cows, sheep (for wool) and hens (for eggs) are validated to ensure the figures are based on reasonable estimates of output per animal in terms of litres of milk per year, number

of eggs laid and kilograms of wool shorn.

Limitations

The methodology used for this report applies a flat output rate per animal regardless of the magnitude of an event. The methodology implicitly assumes that the cost of losses per animal is the same whether a disaster results in one casualty, or 100,000. However, as disasters are generally characterised by the magnitude of their impact and widespread losses, it would not be appropriate to apply the model for small and localised events.

The model estimates the value lost based on one year of gross output of the animal. The loss of productive capacity for output such as wool, milk or eggs over the lifespan of an animal beyond that year are not modelled, thus understating the longer term losses to the economy.

Hothersall (2012) cites several studies where the emotional impact of mass humane slaughter or losses to disasters has been traumatic for farmers, who have worked hard to raise healthy animals only to have them killed prematurely. This suggests that the economic focus of this modeling will substantially underestimate the wider social impacts of livestock losses during disaster. Without disputing the validity of non-economic impacts, it is assumed that the economic incentives to evacuate livestock when necessary (and feasible) will provide sufficient evidence for livestock-oriented preparation actions, without requiring evidence of the non-economic impacts as well.

The modeling in this report relies on a range of sources for estimates of livestock lost, including academic journals and government reports. Where possible, any estimates used are verified from secondary sources, and when a range is reported, the lower end of the range is used for modeling purposes. However, the accuracy and coverage of any modeling suffers from the lack of a complete, official database of livestock losses.

Further, the use of any official sources of information for livestock losses relies on losses being reported by farmers. In many cases if a farmer has been able to cope with the situation themselves, there may be no reason for them to report livestock deaths to authorities. Thus, except in cases where comprehensive surveys of farmers have taken place, livestock losses are likely to be largely under-reported.

2. Australian Context

Agriculture and the Australian economy

Agriculture is a major contributor to the Australian economy, in terms of exports, employment, tax revenue and domestic food supply.

Australia's climate provides it with a significant advantage over other countries in grassland agriculture, and as a result Australia is a lead exporter of wool, beef, lamb and livestock (Bi & Parton, 2008).

Australia's farm exports in the 2010-11 year were $35,529 million, of which $14,824 million were exports of livestock produce. The gross value of farm's livestock production was $21,127 million in the same year (ABARES, 2011). This represents a significant contribution to the wealth of Australia in terms of income to producers, as well as the flow on effects of spending by those producers in the Australian economy.

In the year ended June 2011, 307,000 people in Australia were employed in the agricultural sector (National Farmers' Federation, 2012).

It is estimated that Australian farmers produce approximately 93 percent of the nation's daily domestic food supply (National Farmers Federation, 2012). This means that domestic food prices can be vulnerable to disasters affecting the agriculture industry. Livestock and crop losses to disaster constrain supply, resulting in higher prices for the end consumer. Further, disasters increase the costs of production for farmers, unless these costs can be absorbed, they must also be passed on to the final consumer in order for production to remain viable.

Australian hazards and disasters

Australia has one of the world's most variable climates, where disasters such as drought and bushfires can be followed by flooding, severe

storms and cyclones – all of which have severe consequences for the agricultural sector (Berry, Hogan, Owen, Rickwood & Fragar, 2011). This variability in climate is expected to worsen with climate change, with a wetter, warmer climate predicted for the north and a drier, warmer climate predicted for the south – increasing the frequency and intensity of droughts, bushfires, cyclones and floods (Millar & Roots, 2012).

The more frequent types of disasters to impact on livestock are outlined below.

Fires

Australia is particularly vulnerable to grass and bushfires, due to its long periods of dry, hot weather and vegetation that burns quickly and easily. When fires light after periods of dry, hot weather they spread very quickly, as moisture content in vegetation is lost to the atmosphere. The predominance of eucalyptus trees in Australian forests makes bushfires very hard to control, as they contain large amounts of oil which makes them burn fiercely (EMA, 2006; Geoscience Australia, 2012).

In recent decades, the drive for economic efficiency and competitiveness has led to larger farming operations, with fewer inputs – including a reduction in human resources. This shift to larger grazing areas and assets distributed over wider areas has increased the vulnerability of farms and livestock to fires, as properties are more difficult to prepare and defend against fire. This is further exacerbated by the diminishing population and fire-fighting capacity in rural areas (Whittaker, Handmer & Mercer, 2012).

Livestock are vulnerable to life-threatening injuries from fires through several different ways, including direct burns, radiant heat, suffocation and smoke or flame inhalation that can result in acute pneumonia (DPI NSW, 2013).

Sheep are more prone to fire injuries than other livestock, as they tend to get caught after mobbing themselves into corners, packing against fences or in gullies where they are burnt or suffocated. As a result of their mobbing behaviour, those on the outside are more likely to suffer burns, whilst those in the centre may be relatively unaffected (DPI NSW, 2013; Fahy, 2008).

Cattle tend to be less vulnerable than sheep to fires, as they are taller and can move more quickly. However, they may suffer burns to their legs and feet from crossing burnt ground, or more severe burns if they are trapped by fences (Winterbottom, 2008).

Flooding and severe storms

Floods, severe storms and tropical cyclones are the most frequent and costly natural disasters in Australia. Fires may be more hazardous in terms of deaths and injuries to people, but tend to be less costly in economic terms (Worthington & Valadkhani, 2004).

Flooding in Australia can be grouped into three broad areas;

- Inland rivers – slow onset flooding
- Mountain/coastal rivers – quick onset flooding
- Flash flooding from short, intense rainfall, often the result of thunderstorms (Emergency Management Australia, n.d.)

Slow onset flooding of vast, flat areas in Australia may last for weeks or even months following heavy rain over the catchment areas of river systems. This can lead to major losses of livestock both in the initial flooding, and in the weeks that follow. In the initial phases of flooding, livestock may drown from being caught in fences or flows of flood water. However, secondary impacts such as exposure to cold, wet, boggy conditions, contaminated water or inability to access feed are all serious risks.

Severe storms can result in widespread flooding in Australia, with losses across several states at once. For instance, in April 1990 over one million square kilometres of Queensland, New South Wales and Victoria were flooded when several

weeks of wet weather, partly caused by cyclones, were followed by three days of heavy rain falling on already saturated catchments, where torrential downpours caused almost instant floods. Entire grazing properties were inundated and livestock deaths of up to 1 million were estimated (Emergency Management Australia, 2003). For the purposes of this report, only the confirmed deaths of 300,000 sheep and 11,000 cattle are used, although the Emergency Management Australia (EMA) report indicates that in reality these figures could be much higher.

Flooding is not the only concern when it comes to severe storms and livestock. Sheep, especially those that are recently shorn, are vulnerable when cold and wet for long periods of time. This was evident in the 2005 unseasonable rain in Kattaning, Western Australia which resulted in the loss of 91,000 sheep – most of which were newly shorn weaner sheep, older sheep and those recently off shears (Prosser & Ryan, n.d.).

Drought

Unlike fire and flooding, where rapid onset means that livestock losses occur in a relatively short timeframe, the impacts of drought on livestock numbers are much more prolonged and animal deaths are more likely to be mercy killings due to insufficient feed and water. As such, drought is a less suitable case study for this type of analysis.

3. Historic Livestock Losses

Estimated direct loss per animal

The annual gross output per animal is an appropriate proxy for economic loss in the event the animal is lost in a disaster.
Based on volumes and output to the year ended June 2011, the annual gross output per animal is estimated as follows:

Livestock	Gross output per head
Cattle (non-dairy)	$973
Dairy cattle	$1,530
Sheep, lambs and wool	$137
Pigs	$193
Poultry (meat)	$4
Poultry (egg laying)	$44

Historic events and estimated cost

The table below details a sample of some historic disasters in Australia. Because there is no national database that captures livestock losses in disasters, this table is not comprehensive. Nevertheless, data allows for the quantification of estimated livestock losses in some disasters in Australia over the past 50 years.

Applying the estimated loss in gross output per animal to the events identified below provides the following estimates of gross output lost to the Australian economy from those disasters.

Event	Estimated losses (#)	Total gross output lost $000s
1967 Black Tuesday fire, Tasmania	60,000 sheep 1,350 cattle 24,000 chickens 600 pigs	9,951
1982 Great Southern Storm Darkan, Western Australia	100,000 sheep	13,709
1983 Ash Wednesday fires, Victoria and South Australia	340,000 sheep 18,000 cattle	65,028
1990 Great flood, Queensland, New South Wales and Victoria	300,000 sheep 11,000 cattle	52,382
1990/1991 Hay and Murrumbidgee fires, New South Wales	176,000 sheep 200 cattle	24,333
2005 Kattaning rains, Western Australia	91,000 sheep	12,475
2005 Victoria bushfire	63,243 sheep 557 cattle	9,240
2007 Esperance area storm, Western Australia	43,255 sheep 40 cattle	5,971
2009 Victoria fire	22,707 sheep 1,844 dairy cows 12,968 meat cattle 111 pigs 3,231 chickens	18,603
2010/2011 Victoria floods (Sept 2010 to Feb 2011)	11,321 sheep 392 dairy cows 97 meat cattle 364 pigs 330,184 chickens	5,461
2012 sheep truck overturns, Victoria	400 sheep	55

It should be reiterated that the losses indicated above are based on estimates and are likely to underestimate true losses in many cases. For instance, the confirmed losses of 300,000 sheep and 11,000 cattle in the 1990 floods that covered Queensland, Victoria and New South Wales, are far lower than Emergency Management Australia's (EMA) report of losses estimated to be as high as 1 million sheep (EMA, 2006).

As indicated in the table, the loss of 300,000 sheep and 11,000 cattle in the 1990 floods resulted in a loss of output of over $52 million. To provide an indication of how much this could be underestimated by, the model was re-run using EMA's estimate of 1 million sheep. This returned an estimate of a loss of $137 million in gross output – far in excess of the more conservative estimate of $52 million resulting from confirmed livestock deaths.

The losses described above are a particularly important consideration in measuring the losses in output of the Australian agricultural sector, as they represent an asset that has been completely removed from the economy, often before any of the productive capacity of that asset has been realised. For example, a farmer may have been raising cattle for some time, investing time and money into their growth in order to realise profits from them when they are slaughtered for meat. The death of those cattle before they have reached maturity is an outright loss, as that production cannot be replaced by the farmer.

As Gentle, Kierce and Nitz (2001) observe, loss of business from a disaster to another company within an economy is not a net economic loss, however, a loss of business to an international competitor is an economic cost of the disaster to Australia. A key assumption of this report is that losses in production cannot immediately be remedied from elsewhere within the Australian economy. This is not an unreasonable assumption, as livestock cannot be immediately replaced through reproduction, and import of livestock from another region in Australia merely represents a shift in resource – not an increase in the output of the economy.

Replacing an animal lost to disaster from within the Australian economy may restore the output lost to an individual producer, however it does not mitigate the impact on the total output in the economy. This is because the measurement of production for the entire economy would have included both the value of the animal to have perished and that of the replacement animal. Thus at a national level, the output from the original animal is still lost and the output of the replacement animal would already have been included in agricultural production valuations, so cannot be counted again when shifted to a new farmer.

Flow-on effects

Farmers are not the only producers to suffer a decrease in production due to the loss of livestock. A decrease in production in the agriculture sector also results in downstream production losses for agriculture-dependent industries, such as wholesale trade, transport and mobile labour (Berry et al, 2012).

The Australian Bureau of Statistics does not publish input-output tables illustrating the interdependence between industries within the economy. However, Statistics New Zealand's input-output tables indicate that a supply-side shock decreasing the output of sheep, beef cattle and grain farming, results in a loss of output to the total New Zealand economy that is 2.4 times greater than that experienced by the industry alone (Statistics New Zealand, 2012). It is unfortunate that similar official statistics are not available for Australia. However, the New Zealand data provides an indication of the extent of flow-on impacts that may be faced due to production losses in Australia.

Insurance

While insurance cannot immediately replace the output lost when livestock perish in disasters, it does help farmers return to productive capacity. However, it must be noted that while farmers generally have insurance for their home and properties, many are not insured or are underinsured for their productive assets, including livestock, fencing and machinery (Whittaker, Handmer and Mercer, 2012). This underinsurance reduces the capacity for farmers to recover after disasters, and creates a ratchet effect, whereby farmers' capacity to recover from successive disasters diminishes incrementally with the losses experienced in each disaster (Matyas & Pelling, 2012).

While financial pressures may go some way to explaining why farmers are underinsured for the impacts of disasters, the prevalence of underinsured farmers losing livestock to disasters indicates that the risks are being underestimated. Further, the occurrence of underinsurance coinciding with a lack of preparedness suggests faulty perceptions of the risks faced, as a decision to underinsure

should rationally be offset with other actions to decrease vulnerability to potential hazards.

The section to follow will outline some of the actions that farmers can take to reduce their vulnerability to hazards.

4. Livestock-oriented Disaster Planning

Preparing and defending entire farms and their assets against disasters such as bushfires or severe storms is neither practical nor feasible due to the size of properties and the fact that assets such as machinery and buildings are generally spread across the property. Further, many assets are fixed in place, so cannot be easily moved from danger. Livestock however, are an exception to this, and can generally be moved quickly, at little cost, provided some prior planning has taken place.

In the past 30 years, Australia has lost half of its farmers without a corresponding decrease in agricultural production (Millar & Roots, 2012). Put simply, farmers are doing more, with a lot less. In this context, it is important for farmers to prepare for disasters before they occur in order to reduce the demands on scarce resources should a disaster become imminent.

However, in a study of rural landowners in southeast Australia, Eriksen and Gill (2010), found little direct correlation between fire awareness and formal preparation and planning. While two-thirds of those interviewed perceived there to be a high to extreme bushfire threat in their local area, only 43 percent had prepared a personalised bushfire action plan. Further, it became clear during their interviews that many of those who had a bushfire action plan had not written it down, or discussed it with family members.

Fire planning

In a qualitative study into vulnerability to bushfires in Australia, Whittaker (2008) observed that many actions to protect livestock from fires are not feasible for the entire fire season (such as relocating stock or ploughing paddocks) and may compete with other, more pressing issues facing farmers, such as coping with the presence of a drought. Whittaker found that apart from general property maintenance, most fire preparation activity will generally only take place in an intense period of activity once a threat is imminent. This intense activity must also take place at the same time as preparations to defend homes. In the 2003 Victoria fires, many thousands of livestock perished as the scale of farms meant that farmers were unable to defend their entire property, and had to focus their efforts on their homes and the assets in close proximity (Whittaker, Handmer and Mercer, 2012).

Thus, fire plans and evacuations need to reflect that they may need to be enacted very quickly, and simultaneous to other activities such as evacuating family members, or preparing to defend properties.

Advice provided by Australia's Department of Primary Industries Victoria (DPIV) (2010) on preparations to protect livestock from fires centres around providing land for livestock to shelter on that is protected from the radiant heat of fires and not susceptible to burning quickly.

The DPIV (2010) outlines some key points for designating low risk fire areas on farmland:

- Need to be easily accessed, central
- Located away from bushland or scrub
- Either cultivated, ploughed or heavily grazed
- Grazing animals can be used to reduce the fuel available in designated low-risk areas
- Have enough drinking water for stock to remain for many hours or days, taking into account the likely high temperatures

Other actions to protect livestock include removing equipment and coverings, such as horse blankets and ropes, before hosing them

down to ensure they stay wet (NSW Rural Fire Service, n.d.). Most agencies advise to provide livestock with as much room as possible to roam in a fenced, low vegetation area, as livestock such as cattle are skilful at moving to avoid fire (DPIV, 2010; NSW Rural Fire Service, n.d.)

However, sheep can be difficult to move in the heat and their mobbing instincts can impede movement aware from fires, so more confined low-risk areas are more suitable (DPIV, 2010).

Flood planning

While responding to flooding often has the benefit of weather forecasting, relying on knowledge of previous flood events lead to misguided complacency as there are many factors that can cause rivers to behave differently from storm to storm. For instance, rivers may change course due to erosion and silting, culverts may become blocked, or storm surges may coincide with higher tides – all of which could result in higher than expected flood levels.

Ideally flood planning will involve identifying suitable higher ground to shift livestock to that has adequate feed. Bulls and stallions should be moved earlier when a flood alert is made, as they cannot be kept in confined spaces with other stock (National Centre for Farmer Health, 2011).

In properties without higher ground to move stock to, artificial flood refuge mounds may be an appropriate alternative providing temporary refuge. These are particularly suitable for dry cows or mares, steers, un-calved heifers and geldings (Briggs, 2009). It is recommended that flood mounds are used periodically throughout the year in order to familiarise stock with them (National Centre for Farmer Health, 2011). On dairy farms, dairy bails and milking sheds should be incorporated into flood refuge mounds so feeding and milking can continue during floods.

While flood mounds are not appropriate for all properties, it is recommended that at least 10 percent of the total grazing property should be of low flood risk, and that farms without sufficient higher ground should be ready to relocate livestock when a flood alert is raised (Briggs, 2009).

Flood planning also needs to allow for keeping stock off water-logged land for up to a fortnight while soils dry out (Briggs, 2009).

Sheep will also not seek artificial shelter provided in paddocks, so where possible farmers should look to move wet sheep to sheltered areas to dry out and keep warm. Alternatively, shelter at sheep height, such as thick scrub, or driving sheep into mobs above the flood line can also provide some protection against the cold and wet (Prosser & Ryan, n.d).

Conclusion

Despite the lack of a comprehensive database of livestock losses to disaster in Australia, there is strong evidence that the losses to farmers and the national economy are substantial. The livestock losses used in this report are conservative and only relate to the larger disasters that have occurred in recent history. The true extent of losses has been underestimated, as not all disasters have been considered and of the disasters considered, it is likely that the losses of many farmers were never officially recorded. A more extensive study to identify the full extent of livestock losses to events such as fires and severe weather would serve to strengthen the argument that the cost of livestock-oriented preparation activities are modest compared to the potential losses faced by farmers and the economy as a whole.

The combination of underinsurance of livestock and low disaster preparation rates suggests that farmers are underestimating the risks that they face or are underestimating the value of livestock-oriented preparation activities in the face of competing demands for their time and energy. Given the impact on the Australian

economy from loss of livestock in previous disasters, the issue is clearly of nationwide significance.

A useful extension of this study could incorporate a comprehensive analysis of the costs to farmers for preparation and evacuation activities in order to support a complete cost-benefit analysis of disaster planning. Such an analysis could serve as a useful tool for education programs and to support farmers' decision making when assessing the opportunity costs of their time and money against the potential losses they face from inaction.

The subsequent flow-on losses from the decrease in production resulting from livestock deaths have serious implications for the Australian economy, as decreases in agricultural output have downstream impacts in terms of production and employment in agriculture dependent industries. The wider implications of livestock losses suggest a place for livestock-oriented considerations in state-based emergency management plans in order to address some of the impacts of disaster onto the wider economy.

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