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Dam safety management for sustainable farming businesses and catchments

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ABSTRACT

In most countries, owner responsibility exists under Common Law to manage and maintain dams according to current standards. However, farm dam safety in Australia is being flouted and the sustainability of farming businesses compromised because of the potential and severe consequences of dam failure. This paper explores management and policy issues associated with safety of farm dam water storage through a comparison of developments in two Australian states against international benchmarks. Historical review and a longitudinal study over a 12-year period provides the basis for case analysis and demonstrates the application of the benchmarked model policy selection guidelines. Research results show South Australia is lagging international best practice in a number of ways whilst Tasmania provides leadership. The contribution of this paper is a regulatory mix analysis approach, incorporating a cost-effective spillway safety engineering/accounting tool, developed and demonstrated through Australian case studies, that can be applied by any jurisdiction wanting to check and/or improve its farm dam safety management and provide a clearer analysis of the social and environmental costs and threats associated with on-farm dam safety issues.

1. Introduction

Water resources management is essential for sustainable agriculture in a climate of water scarcity (Ashraf et al., 2007; Khalkheili and Zomani, 2009). Dams are the "lifeblood" of most farming businesses as they provide stocks of essential water supply for irrigation and other farming activities (Lewis, 2002). There are at least 735,000 farm dams in Australia (Baillie, 2008) which demonstrates the reliance of Australian farming business on these structures. A problem exists with private/farm dam safety in that thousands of dam structures have failed and many more pose significant safety threats. The Australian National Committee on Large Dams (ANCOLD) in 1992 estimated that 23% of farm dams in NSW failed (ANCOLD, 1992). In Tasmania a number of private dams have failed in the past 80 years with serious consequences (Ingles, 1984; Pisaniello, 1997), and currently some 500 of the 8000 registered dams pose significant safety risks (Ditchfield, 2008, *perscomm*; DPIWE, 2005, 21). In Victoria around 1000 of the 300,000 farm dams are very dangerous (Lake and Bond, 2006, 290), and Lewis and Harrison (2002) report that at least 10 significant failures have occurred in Victoria in the last decade. Most recently in South Australia, a 600 ML farm dam on Kangaroo Island burst following severe rainfalls in July 2009 causing significant damage downstream to both private and public property (ABC News, 2009).

Climate change has recently increased the likelihood of unusually heavy rains in Australia which is likely to become more frequent in areas of middle and high latitudes (IPCC, 2007): hence dams not designed to handle such extreme flood events will fail more frequently. Dam failure for a farming business can mean: no longer being able to water valuable crops, the subsequent loss of those crops, serious inconvenience to farming activities, substantial cost to repair or replace the dam, and possible liability for downstream consequences (Lewis, 2002). Whilst there are many conflicting definitions of sustainability, the notion has been defined by authors as the goal of providing future generations the opportunity to generate the goods and services required to achieve their objectives (Wichelns and Oster, 2006). Hence, management of a farm dam to maintain its performance, structural integrity and safety is vital not only for the sustainability of a farming business in the present, but also for future generations. In addition, sound management is also important for the safety and sustainability of the downstream community and environment. Sustainability accounting provides a tool for identifying and making transparent the costs to business and the community associated with dam failure (Schaltegger and Burritt, 2010). However, a major challenge to privately owned dam management is the lack of on-farm water management records, reports and assessments (Gibbings and Raine, 2005) and often the most basic costs are ever brought to light, such as, the focus on deaths caused by dam failure.

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Failures of large dams are more spectacular than those of smaller dams and receive much more attention. However, small farm dam failures, particularly those of privately owned farm dams, occur far more frequently (Lewis and Harrison, 2002; Pisaniello and McKay, 2007). Small dam failures internationally have had disastrous consequences. For example, in China the Shimantan and Banquia dams failed in 1975 because of the cumulative failure of 60 smaller upstream dams, resulting in the death of 230,000 people (Si and Qing, 1998). In Italy, the Stava dam near Trento failed in 1985 and while releasing only 180 ML of tailings material, it killed 268 people and caused serious environmental damage (Engels, 2005). In the United States: the Kelly Barnes Lake dam, only 8 m high, failed in 1977 killing 39 people; the 8 m Lake Lawn dam in Colorado, which stored only 830 ML, failed in 1982 killing 3 people and causing US$31 million in damage despite warnings and evacuation (Hiser and McDonald, 1989); the 5 m Evans and Lockwood dams, which held only 89 ML and 39 ML of water respectively, both collapsed in a cascade manner in 1989, killing 2 people (Graham, 1999); and the 13 m Kaloko farm dam in Hawaii overtopped and failed due to a blocked spillway in 2006 resulting in the deaths of 7 people and widespread environmental damage (HIDLNR, 2010). In Indonesia the Situ Gintung earthen dam, only 10 m high failed by overtopping in 2009 killing around 100 people and causing widespread damage in Jakarta (The Associated Press, 2009).

Graham's (1999) study of dam failures in the US that resulted in fatalities from 1960 to 1998, found that dams less than 15 m high (i.e. the typical height range of smaller "private" dams) caused 88% of deaths. This demonstrates that without appropriate design, construction, maintenance and surveillance, poorly managed small dams pose both significant individual and cumulative/cascade threats (Pisaniello and McKay, 2007), and this mis-management can cause considerable human, property, economic and environmental losses (Ashraf et al., 2007). Burritt et al. (2002) encourage the adoption of environmental management accounting to reveal the physical and monetary aspects of environmental impacts on the organisation, such as the farm, and the organisation's impacts on the environment. At present such richness of data is absent from the on-farm dam safety debates and policy. Hence, this paper focuses on the appropriate management of private/farm dam structures and adequate accounting, accountability and assurance processes for achieving sustainable farming businesses as well as sustainable and safe catchments in the context of (a) international experience and (b) developments in two Australian States with contrasting practices: Tasmania and South Australia (see Fig. 1).

The suggestion that farm dams are poorly managed and present hidden environmental and safety threats is examined. The key question addressed is how can 'adequate' private dam management through safety accounting, accountability, and assurance best be encouraged? The paper makes use of multiple methods, namely comparative literature review, qualitative key policy actor feedback, spillway engineering modelling, historical review and longitudinal case study, each employed at various stages for different, yet inter-related purposes as follows. In Section 2, policy and management issues associated with farm dam safety are explored. Available international literature is then examined comparatively to establish benchmarks for farm dam safety policy ranging from "minimum" to "best practice", together with guidelines on which benchmarks should apply in varying circumstances. Section 3 presents a best practice model as identified from Tasmanian practice and key-actor feedback, as well as a newly developed cost-effective spillway safety engineering/accounting tool. Section 4 concentrates on South Australia, providing first a historical review on dam safety and then a longitudinal analysis over a 12-year period of a set of farms which provides the basis for case analysis and demonstrates the application of the benchmarked model policy selection guidelines. Sections 5 and 6 provide discussion and conclusion on the regulatory mix analysis approach that has been developed here and demonstrated through Australian case studies. The theoretical foundation of the paper is provided by regulatory mix theory which describes the requirement for policy that can address multifaceted environmental challenges (Gunningham and Sinclair, 1999, 2006) and can assist in the creation of the optimal policy mix for dam safety management.

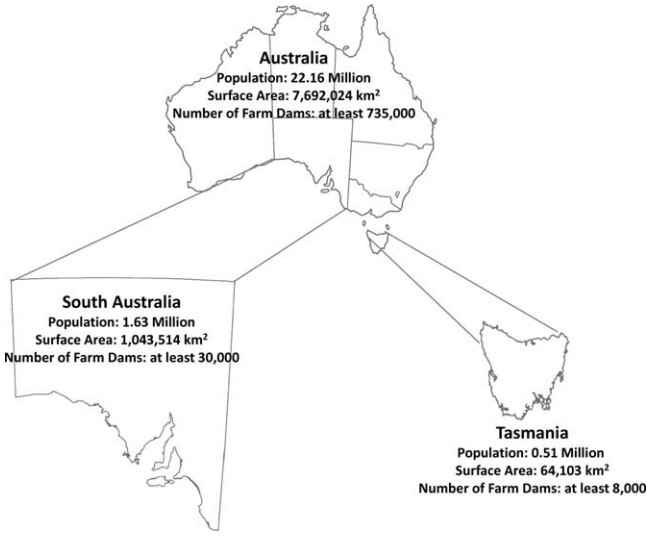

Fig. 1. Two Australian States with contrasting dam management practices: Tasmania and South Australia (McMurray, 2004, 2007; DPIWE, 2005; Baillie, 2008; Ditchfield, 2008, *perscomm*; ABS, 2009).

2. International benchmarks in private dam safety management

In most countries, owner responsibility exists under Common Law to manage and review dams according to current standards to minimise the risk of failure (McKay and Pisaniello, 1995; Pisaniello and McKay, 2007). In Australia, these standards are set by the Australian National Committee on Large Dams (see ANCOLD, 2000a,b, 2003). However, many jurisdictions in Australia and overseas have found that it is not enough to rely solely on Common Law responsibility to protect downstream communities, property and the environment from poor dam safety management practices. A number of management mechanisms in addition to Common Law and statutory command and control are available to ensure dam safety. A contrasting mechanism is for government to use an information strategy, through the reporting of accounting data to help inform and educate stakeholders of potential risks and liabilities (Gunningham and Grabosky, 1998). However determining the most appropriate combination of management mechanisms for different jurisdictions with different circumstances can present a number of issues. These issues are illustrated in the Australian context in Section 2.1. The available management mechanisms are then discussed in Section 2.2 based on international review. An international standard or benchmark against which the circumstances of differing jurisdictions can be assessed for achieving adequate management is also established in Section 2.2.

2.1. Key issues from Australia in achieving 'adequate' private dam safety accountability and assurance policy

The Australian States' policy responses were reviewed in Pisaniello and McKay (1998a, 2005, 2007). These reviews found that NSW, Victoria and Queensland have made good progress in managing the threats posed by hazardous privately owned dams. At the