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International small dam safety assurance policy benchmarks to avoid dam failure flood disasters in developing countries

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SUMMARY

In developing countries small dam failure disasters are common yet research on their dam safety management is lacking. This paper reviews available small dam safety assurance policy benchmarks from international literature, synthesises them for applicability in developing countries, and provides example application through a case study of Vietnam. Generic models from 'minimum' to 'best' practice (Pisaniello, 1997) are synthesised with the World Bank's 'essential' and 'desirable' elements (Bradlow et al., 2002) leading to novel policy analysis and design criteria for developing countries. The case study involved 22 on-site dam surveys finding micro level physical and management inadequacies that indicates macro dam safety management policy performs far below the minimum benchmark in Vietnam. Moving assurance policy towards 'best practice' is necessary to improve the safety of Vietnam's considerable number of hazardous dams to acceptable community standards, but firstly achieving 'minimum practice' per the developed guidance is essential. The policy analysis/design process provides an exemplar for other developing countries to follow for avoiding dam failure flood disasters.

1. Introduction

Dam failure disasters are a great concern all over the world especially in developing countries where dam safety has been given little attention (WB, 1990; Dam, 2011). In developing countries, small dams account for over 90% of dam failure disasters which often have catastrophic consequences for the downstream community, infrastructure and the environment (ICOLD, 2011). A large number of notable failures of small dams with disastrous consequences have occurred throughout the world. For example, a small 10 m high, 2000 ML earthen dam outside Jakarta in Indonesia failed by overtopping in 2009 (The Associated Press, 2009). At least 96 people were killed, 130 displaced and significant infrastructure and property was lost and damaged (The Associated Press, 2009). The Shimantan and Banquia dams failed in 1975 in Henan province in Central China because of the cumulative failure of 60 small dams in the upstream catchment area. Around 230,000 people were killed, more than 1 million ha of land were inundated and over 100 km of the Beijing–Guangzhou railway line damaged in this disastrous cumulative dam failure (Fu and Qing, 1998; Fuggle and Smith, 2000). Furthermore, these structures not only age but over time, the physical areas of catchments have changed and continue to change significantly due to human activity meaning dam failure disasters that threaten life are set to increase (Jothityangkoon et al., 2013).

In developing countries, growing water resources infrastructure development combined with older infrastructure deterioration and mismanagement has meant organisations around the world are looking for tools and methods for how to improve the situation, including increased data collection, performance measurement and rankings (Berg and Corton, 2007). Amongst these methods, benchmarking methodologies have emerged as a valuable information system for policymakers and managers that pinpoints the areas that should be targeted for future initiatives whilst allowing them to evaluate the impacts of past interventions (Berg and Corton, 2007). Benchmarking is the process of comparing and measuring policy and practice against others to gain insights into the optimal measures for rapid improvement towards best-practice performance (Bowerman et al., 2002; Yasin, 2002). The process of benchmarking has been used extensively to rank and implement

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a wide variety of policy management practices and techniques (Yasin, 2002) and is useful for issues such as farm dam safety management (Tingey-Holyoak et al., 2011). In the developed world, benchmarks for dam safety management are receiving increased attention from both academics and practitioners because many small dams are neither constructed nor managed adequately[3] (Bradlow et al., 2002; Tingey-Holyoak et al., 2011). However, in developing countries there exists a lack of awareness of the dangers of poor dam safety management practice and impacts (Levitan, 2014; Dam, 2011), policy is often not strong or well-enforced and cumulative dam failure effects are more likely (Levitan, 2014). Therefore, internationally benchmarked dam safety assurance policy guidance is needed to help developing countries design policies (Jha et al., 2012) that will ensure dams are constructed and risk managed to an acceptable standard, and as cost-effectively as possible, in order to save downstream lives, business, property and the environment that are too often lost as a result of dam failures.

Vietnam has one of the largest dam systems in the world. The dam network comprises over 750 medium and large dams and thousands of small dams in close proximity (Veale et al, 2014; Dao et al., 2000; Silver, 1999; WB, 2004). But at present, the country has no national record of either small dams or their problems, for example location, dam type and size, hazard rating, condition, etc. There has been no systematic collection of data on dam failures and there have been no specific approaches to determine associated impacts or economic losses of failure (Nguyen, 2007). Ad hoc evidence suggests that many dam safety problems and notable dam failures have occurred in various provinces in Vietnam but have often been unreported (Nguyen, 2003). These failures have taken hundreds of lives and have caused devastating impacts on property and the environment (Nguyen, 2007; Silver, 1999). Even from just this limited recorded information, it is apparent that the costs of dam failures, including the associated threats to the security of agricultural produce (Gohar et al., 2015) are significant (Nguyen, 2003, 2007; Silver, 1999; Dam, 2011). Policy tools to drive better practice and establish levels of standards for operating are required (Veale et al., 2014; Yasin, 2002). Therefore, the research aims to investigate the available dam safety policy benchmarks[4] and synthesise them to enable application to developing countries, and then apply these specifically to the case of Vietnam in an exemplary way. The core research question addressed is "*What international dam safety policy benchmarks can assist Vietnam to assure small dams are constructed and managed to an acceptable safety standard?*"

The remaining sections of the paper are structured as follows: Section 2 reviews available literature and synthesises international dam safety policy benchmarks to identify models, guidelines and selection criteria for determining necessary assurance models for developing countries. Section 3 provides results of the micro level on-site dam safety surveys in Tan Moc commune, Bac Giang province. In Section 4, a descriptive analysis of relevant macro level policy, laws and regulations on small dam safety management in Vietnam is presented and then analysed comparatively against the international benchmarks established. Section 5 provides a summary and discussion of the results and the associated implications, Section 6 concludes the paper with the answer to the core research question and with final discussion of the implications for Vietnam in particular and developing countries in general.

2. Review and synthesis of international benchmarks and guidelines for necessary policy in any jurisdiction including developing countries

Considerable work on international dam safety policy benchmarks has been done based on comprehensive review and comparative assessment of dam safety management responsibility, accountability and assurance practices in a large number of countries (Bradlow et al., 2002; Pisaniello et al., 2012; Tingey-Holyoak et al., 2011). Underpinning these studies are the three benchmark models initiated by Pisaniello (1997) that are "best practice", "average practice" and "minimum practice". These three models are in line with the socio-ecological objective to balance the need for public and environmental protection (Sanchez et al., 2014) with the imposition of restrictive and expensive requirements on builders and owners. The models, the criteria necessary to apply them and their application to Australian jurisdictions have been reported most recently in Pisaniello et al. (2012). However, these models were developed primarily based on and for application to developed countries. In contrast, the World Bank's "regulatory frameworks for dam safety" (Bradlow et al., 2002) were derived to include application to developing countries. The problem is that the World Bank frameworks are descriptive only (see Section 2.1 below) and do not provide for any criteria on how to apply them for varying circumstances as do the Pisaniello (1997) models (see Pisaniello et al., 2012; Tingey-Holyoak et al., 2011). Hence, there is a need to synthesise the Pisaniello (1997) models with the Bradlow et al. (2002) frameworks in order to establish updated models and criteria representing minimum to best practice that is applicable to varying circumstances (ie the number of hazardous dams within a jurisdiction and the number that are deficient) for both developed and developing countries. In this Section the World Bank models will firstly be described (Section 2.1) and their synthesis with the Pisaniello (1997) models will then follow (Section 2.2).

2.1. A summary of World Bank's regulatory frameworks for dam safety (Bradlow et al., 2002)

The Bradlow et al. (2002) study involved a detailed comparative assessment of dam safety regulatory frameworks in 22 countries[5] including developing countries such as China and India. The study provides information to policy makers and technical experts in countries that are planning to develop new or to modify existing regulatory frameworks for dam safety. It highlights the main similarities and differences in the approaches adopted by the 22 countries, enabling general precedents to be set for both "Essential" and "Desirable" elements of a dam safety regulatory scheme. The essential elements include those that any regulatory scheme needs if it is to be capable of performing the most essential functions with regard to dam safety, such as assuring that dams satisfy minimum international safety standards. The desirable elements are simply additional ones that can be adopted by regulators for providing a higher level of dam safety assurance. This subsection reviews the principal part of Regulatory Frameworks for Dam Safety by Bradlow et al. (2002): 'Part 3: Essential and Desirable Elements for Dam Safety'.

[3] Adequate construction here refers to ensuring adequate planning, design and construction of new dams or upgrade of existing dams, especially with respect to the three key areas of dam engineering: structural integrity, spillway flood capability and earthquake resistivity. Adequate management refers to appropriate surveillance, maintenance and review of existing dams – items that should be reviewed periodically include hazard rating (as this can change throughout the life of a dam due to new community developments downstream) and spillway flood capability (due to changes in engineering standards and design rainfalls brought about, for example, by climate change). See also ANCOLD (2003) and Pisaniello et al. (2012).

[4] That is, internationally benchmarked policy elements ranging from minimum to best practice that governments can use to assure the community that dam owners/managers construct and manage dams to an acceptable risk standard.

[5] The counties were selected based on the availability of information about their dam safety regulatory frameworks and comprised Argentina, Australia, Austria, Brazil, Canada, China, Finland, France, India, Ireland, Latvia, Mexico, New Zealand, Norway, Portugal, Romania, the Russian Federation, South Africa, Spain, Switzerland, the United Kingdom, and the United States.