

## **Small dam safety problems in Vietnam and associated responsibility and accountability: evidence from a rural commune**

**Tuyet Thi DAM**✉

Centre for Accounting, Governance and Sustainability  
University of South Australia  
Way Lee Building, City West Campus  
North Terrace, Adelaide SA 5000  
Australia  
Tel: +61 8 8302 7294  
Fax: +61 8 8302 0992  
Email: [damtt001@mymail.unisa.edu.au](mailto:damtt001@mymail.unisa.edu.au)

**John D. PISANIELLO**

Centre for Accounting, Governance and Sustainability  
University of South Australia

**Roger L. BURRITT**

Centre for Accounting, Governance and Sustainability  
University of South Australia

### **Abstract:**

*This paper examines the prevalent safety problems associated with small dams in Vietnam and the contributing factors to the problems using a rural commune in Vietnam as an indicative case study. Ten on-site dam surveys were conducted in Tan Moc commune. Fifteen semi-structured interviews were conducted within five key stakeholder groups. The surveys suggested that all ten dams surveyed were rated 'High' hazard and were at high risk of failure because of physical and management inadequacies. The interviews indicated that floods were the dominant cause of dam safety deficiencies and dam failures. Human factors were seen as important or as more important for dam safety than the impacts of natural extremes.*

### **Key words:**

Environmental responsibility, environmental accountability, small dams, triangulation method, Vietnam

## 1. Introduction

Although dams have made a substantial contribution to storing and managing water – the vital resource needed to sustain human development (ICID 1999; WCD 2000) - the safety of dams is a great global concern. A large number of dams all over the world are classified as ‘high’ hazard and are at high risk of failure. For example, about one third of over 80,000 dams surveyed in the National Dam Safety Program in the United States (US) pose a ‘high’ or ‘significant’ hazard to lives and property in downstream areas (FEMA 2009). Results of a World Bank dam safety assessment indicate that thousands of people are at risk of death downstream from the 25 hazardous dams surveyed in India (Rao 2008). According to a survey conducted by International-Rivers, safety maintenance and management is under invested worldwide (IR 2009). Many dams in the world are getting old but neither information nor statistics on funds for dam safety maintenance exists (IR 2009). About 5,000 dams around the world were built over fifty years ago based on safety criteria available at the time. Most of these aging dams have not been built to adapt to erratic changes of infrastructure and hydrological patterns caused by climate change (IR 2009). Increased weather extremes and severe floods can also trigger dam bursts thereby reinforcing concerns about ongoing maintenance and close supervision of dam safety condition and the execution of proper repair (WCD 2000; IR 2009).

Dam safety is a matter of high importance because dam failures are seen as being potentially as destructive as earthquakes, hurricanes, air crashes, fires and explosions (Smith 1989; DSE 2007). Dam failures can cause great harm to life and human health as well as adverse social, economic and environmental impacts (WCD 2000; UNEP 2004, 2006; He et al. 2008; WB 2008; Pisaniello 2009, 2010; Pisaniello et al. 2011). Many notable dam failures have occurred throughout the world. For example, 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 hectares of land were inundated and over 100 km of the Beijing-Guangzhou railway line damaged in this disastrous cumulative dam failure (Fu & Qing 1998; Fuggle & Smith 2000). In 1993, more than 1,200 lives were lost as the Gouhou dam failed in Qinghai Province (Fuggle & Smith 2000). He et al. (2008) provide an extensive review of failure consequences from 1954 to 2003 in the three highest failure rate countries namely China, Spain and the US. In general, a wide range of dam failure disasters have occurred and have caused numerous fatalities and considerable economic losses. For example, 3,481 dam failures happened in China over the 50-year period examined; 30,000

people were killed, 5 million houses destroyed and 1 million hectares of farmland inundated (He et al. 2008). Within Europe, the failure of the Maupassant dam in southern France in 1959 claimed over 450 lives (Smith 1989). In addition, the Stava tailings dam failure in Italy in 1985 killed 268 people, destroyed 62 buildings and caused serious environmental damage (Chandler & Tosatti 1995).

Much of the current attention is paid to the safety of large dams where the consequences of failure would be devastating for the downstream community, property and environment. Although small dam safety poses equally significant threats (Pisaniello & McKay 2005, 2007), there are insufficient data for small dam safety management. According to ICOLD (2007), dams of 15 metres and higher in height, or dams of 10 to 15 metres in height and a storage capacity of over 3000 ML are defined as large dams. Small dams are all other dams. Small dams are often not properly designed and constructed based on engineering criteria (WB 2008). The operation and management of small dams are also not closely regulated (WB 2008). As a consequence, small dams represent higher risks of individual failures or cascade/cumulative failures than large dams (Pisaniello & McKay 2005, 2007; WB 2008). In fact, the failure of small dams occurs far more frequently than that of large dams (Pisaniello & McKay 2007; He et al. 2008; WB 2008). For instance, over 96% of the total failures (3,356 out of 3,481) in China were small dams during the 50 year period between 1954 and 2003 (He et al. 2008). Moreover, the annual total cost of small dam failure can be more serious than the cost associated with large dam failure (Pisaniello & McKay 2007). Hence, there is a need for research into the safety and regulation of small dams. The purpose of this paper is to investigate the physical signs of problems associated with small dam safety in Vietnam – a country with a considerable small dam population, and to explore factors contributing to the current dam safety problems in Vietnam.

## **2. Small dam safety in Vietnam - literature review and research questions**

Vietnam offers an appropriate context for researching small dam safety management because the country has one of the largest dam systems in the world along with China and the US (Dao et al. 2000). The dam network in Vietnam comprises over 750 medium and large dams and thousands of small dams (Silver 1999; Dao et al. 2000; WB 2004). Small dams are mainly used for local drainage and irrigation. Some of them are also supplying water for industry, domestic use, tourism and aquaculture. A few dams are also able to generate hydro-electricity (Le 2005).

Small dams are often situated in close proximity to residential areas, and have direct impacts on productivity and the livelihoods of downstream communities. Farmer/user associations or committees of local people are responsible for the operation and management of these dams to assure food security and supply for living activities. Small dams therefore make a substantial contribution to the water resources development as well as socio-economic development of Vietnam, particularly in rural areas where 70-80% of the population makes a living from agriculture (Silver 1999; Luu 2005). The Vietnamese Ministry of Agricultural and Rural Development specifies that small dams are a fundamental part of hunger eradication and poverty reduction in poor rural provinces in Vietnam (MARD 2009). For these reasons, the management of small reservoirs and dams needs to be considered as equally important as to that of large dams.

The safety of small dams however is a key challenge to dam catchment management in many rural provinces across Vietnam. There is currently no national dam safety program or an overall strategy for the safety management of dams in general and small dams in particular (Nguyen 2007). The majority of small dams are owned by the government and are currently operated and managed by farmer or user associations or local people's committees (NAV 1998; GVN 2007). The current regime has created the situation that no specific individuals or organisations take legal responsibility for proper dam safety management and dam failures (Tran & Nguyen 2008). The problems associated with public ownership but no public control are based on opportunities for organisations and individuals to gain the benefits from dams while overlooking responsibility for adequate surveillance and maintenance.

At present, Vietnam has no national record of either small dams or their problems (Nguyen 2007). Nearly 100% of small dams are soil/earth dams which were built since the 1970s and during the Vietnamese war (WB 2004; Nguyen 2007). A majority of dams were built with inferior design and poor construction standards because of the lack of adequate design knowledge, construction equipment, materials such as cement and concrete, and construction technology (WB 2004; Nguyen 2007). For many years, maintenance of and investment in safety has been insufficient (Adger 1999). This deficiency can be seen through soil erosion and sediment accumulation over time which have decreased storage capacity and blocked runoff and water flows. The risk of dam failure disasters in a number of catchment areas therefore remains high. High population density, the tropical climate, mountainous terrain and proximity of dams will also exacerbate the consequences of any failure (WB 2003).

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). Many dam safety problems and notable dam failures have occurred in various provinces in Vietnam but have often been unreported. These failures have taken hundreds of lives and have caused devastating impacts on property and environment (Silver 1999; Nguyen 2003; 2007). For example, the 2,000 mega litre (ML) reservoir of Nha Tro dam failed in Nghe An province in 1978 causing the death of 27 people and damaging thousands of hectares of rice fields. In 1986, the overtopping failure of Dau Tieng dam damaged 3,452 hectares of mature rice (ready for harvesting), 1,144 hectares of early rice (not ready for harvesting), 1,197 hectares of farming products and 871 hectares of fruit, flooded 3,114 houses and disrupted 47 houses. The failure of the 500 ML Buon Bong dam storage killed more than 30 people and caused thousands of dollars of damage. In 2002, Am Chua dam in Khanh Hoa failed but no records of damages and losses were available (Silver 1999; Nguyen 2003; 2007). In 2009, the 250 ML reservoir of Z20 dam failed and about 200 m of railway embankment was destroyed. A number of trains from the North to the Central and the South were cancelled (Nguyen 2010).

For the reasons discussed above, the safety of small dams and responsibility and accountability for their management in Vietnam are matters of great concern. However, the degree and scope of the safety issues are unexplored because little information has been recorded and reported publicly. The responsibility and accountability associated with unacceptable hazardous dams and/or dam failures remains to be examined. In order to begin filling the gap in the understanding of small dam safety management in Vietnam two research questions are addressed:

What are the physical signs of problems associated with small dam safety in Vietnam?

What are the factors contributing to small dam safety problems in Vietnam?

In this paper, dams refer to water storage dams that can be used for irrigation, drainage, water supply, flood control and hydropower. Small dams are all dams of less than 15 m in height and with a storage capacity of less than 3000 ML (GVN 2007). This definition of small dams is similar to ICOLD's definition (2007).

### 3. Research methodology

#### 3.1 Research design and data collection methods

The research was designed in the following two stages.

Stage 1: Fifteen qualitative semi-structured interviews were conducted within five key stakeholder groups. Stakeholder interviews were conducted face-to-face between 10 September and 21 October, 2010. The interviews involved 3 stakeholders in each group including:

- Group 1: Policy regulators, members of Water Resources Administration, Ministry of Agriculture and Rural Development or members of Vietnamese government's policy and laws Board on dam safety management, who take the most responsibility for dam safety management at the macro level.
- Group 2: Researchers and consultants, who are working in the dam safety management field in national research institutions and international organisations in Vietnam.
- Group 3: Local authorities, members of Bac Giang province's Water Infrastructure Management Department, Luc Ngan district's Department of Agricultural and Rural Development and Tan Moc commune People's committee.
- Group 4: Local dam managers who are operating and managing dams in Tan Moc commune.
- Group 5: Members of the local community who are living close to dams and bearing the dam safety threats in Tan Moc commune.

Stage 2: An embedded case study was conducted containing ten on-site surveys, which were conducted on purposively selected dams in Tan Moc commune, Luc Ngan district, Bac Giang province - Vietnam (Figure 1). All dams selected for on-site surveys in the field work had to satisfy the following two criteria: (1) dams of less than 15 m in height and with a storage capacity of less than 3000 ML (small dams) (GVN 2007); (2) 'Significant' or 'High' hazard dams based on an initial assessment of the dam size, living activities and economic development in the downstream inundation area (ANCOLD 1994, 2003). The dam surveys were undertaken between 28 September and 2 October, 2010.

### 3.2 Research context

All dams for on-site surveys were selected in Luc Ngan district, Bac Giang province about 50 km from Ha Noi - the capital city of Vietnam. Luc Ngan district is located between 21015' - 21035'N and 106033' - 106052'E in the northeast of Bac Giang province in Vietnam (DWIM 2006). The district covers an area of 1,012.2 km<sup>2</sup> and its population in 2004 was 196,516 (Figure 2).



Figure 1 Ten sample dams that were conducted in on-site surveys

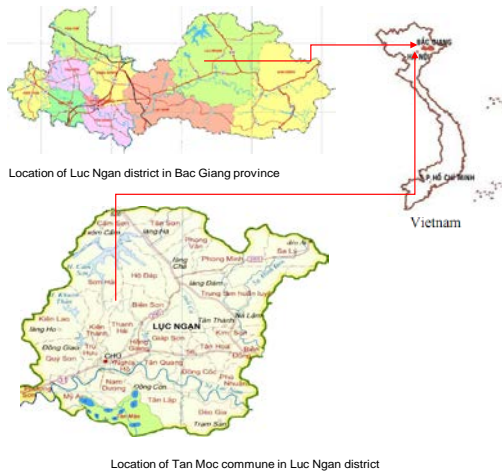


Figure 2 The study sites and their locations in Vietnam

The reason for selecting Bac Giang province as an overall indicative case study in this research is that Bac Giang is one of the provinces having a large number of dams, mostly small dams, in Vietnam (DWIM 2006, 2009; MARD 2009). Available data show that dam failures occur every year and have caused severe property and environmental damage in the province (Nguyen et al. 2009; Tran 2009; Nguyen 2010). ‘Luc Ngan's topography is hilly and steep with an average height ranging from 400-600m (DWIM 2006, p. 3).’ The topography is divided by many hills and rivers thereby creating a number of deep valleys where many reservoirs and dams are located (DARD 2004; DWIM 2009). This steep topography exacerbates probability and severity of dam failures to the local community who live and are accommodated in immediate downstream areas. Some recent historical dam failures in Luc Ngan district, Bac Giang province are listed in Table 1.

**Table 1 Historical dam failures in Luc Ngan district, Bac Giang province, Vietnam**

Dam failure	Commune	Year of failure	Cost of dam repair	
			Vietnamese Dong (1000 VND)	Equivalent US dollar (USD)*
Non khuat	Hong Giang	2008	5,000,000	312,500
Ran	Tan Moc	2008	400,000	25,000
Ia	Tan Moc	2008	200,000	12,500
Chao	Giap Son	2008	5,000,000	312,500
Da Mai	Giap Son	2008	600,000	37,500
Bau	Giap Son	2008	700,000	43,750
Hoa Quang	Nam Duong	2008	6,000,000	375,000
Deo Gia	Deo Gia	2008	3,000,000	187,500
Bien Dau	Bien Dau	2008	300,000	18,750

**Note:** \* In 2008, 1 USD = 16,000 VND on average over the entire year.

**Source** Records were provided by one of the local authority participants (G3.3)

### 3.3 Data analysis methods

For Stage 1, the constant comparative method (Glaser 1965; Tesch 1990; Sivesind 1999; Boeije 2002; Carter 2010; Hammersley 2010) was used for interview data analysis. Comparison was constantly used as data was coded and analysed. Answers by each interviewee were scrutinised and compared to evaluate consistency as well as conflicts in their conversations. In addition, answers to each question were scrutinised and compared across interview participants to identify similarities and differences among different stakeholders.

For Stage 2, an extensive set of photos were taken and stored separately for each individual dam. In addition, on-site survey assessment of each dam was written on a dam inspection checklist developed from two publications that are: (1) ‘Your dam - your responsibility: A guide to managing the safety of farm dams’ by the Victorian Government Department of Sustainability and Environment (DSE 2007); and (2) ‘Dam safety guidelines: inspection and maintenance of dams’ by the Water Management Branch, Ministry of Environment, Lands and Parks, British Columbia (MELP 1998). The two publications are dam safety management guidelines in line with international acceptable practices for small earthen dam review and inspection (Pisaniello 1997, 2010; Pisaniello & McKay 2005, 2006). All photos taken in the on-site dam surveys were analysed by the photo-interpretation method which is widely used to assess objects or semiotics (Slater 1998; Demeritt 2001; Rose 2001; Brewer et al. 2005).

## **4. Results**

### **4.1 Results for Research Question 1: Physical signs of problems existing with small dams in the study area examined in Vietnam**

From the stakeholder interviews, the most prevalent safety problems of small dams in Vietnam include: erosion, seepage, structural cracking, inability to store design water capacity, vandalism, inappropriate spillways, traffic damage, settlement, sinkholes, animal burrows and excessive vegetation (see Table 2 for greater details).

**Table 2 Common problems of small dams in Vietnam cited by key stakeholders**

<b>ID</b>	<b>Problems of small dams in Vietnam</b>	<b>No. of participants</b>	<b>Percentage of participants*</b>
1	Erosion damage	14	93%
2	Seepage	14	93%
3	Cracking	11	73%
4	Inability to store design water capacity because of silting and/or leakage	10	67%
5	Blocked spillway	10	67%
6	Inappropriately designed spillway	10	67%
7	Vandalism damage	10	67%
8	Damaged by traffic	9	60%
9	Outlet leakage	9	60%
10	Outlet broken	9	60%
11	Settlement	6	40%

12	Damage from animal burrowing	5	33%
13	Excessive vegetation and/or trees	5	33%
14	Sinkholes	3	20%
15	Slides and/or slumps	2	13%
16	Low area on the crest of dams	2	13%

**Note** \*On the basis of fifteen participants

Results from the on-site dam surveys demonstrate that all ten dams surveyed in Tan Moc commune, Luc Ngan district in Bac Giang province are seriously degraded and poorly maintained. 100% of the dams surveyed are highly hazardous and have the potential to fail with disastrous consequences. The current condition and associated maintenance levels of the sample dams are extremely poor and unacceptable. Characteristics of the ten sample dams are summarised in Table 3.

**Table 3 Characteristics of ten sample dams**

Dam No.	Year built	Height (m)	Storage capacity (ML)	Purposes of dam	Hazard rating	Year repaired and/or maintained
1	1963	4	600	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	2007
2	1970	6	800	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	1986 and 2008
3	1973	4	500	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	2007

4	N/R	5	500	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	N/R
5	1975	6	2500	Irrigation and drainage for Tan Moc and Phi Dien communes	High because many dwellings are located downstream of and in close proximity to the dam.	2008
6	1972	5	2000	Irrigation and drainage for Tan Moc and Phi Dien communes	High because many dwellings are located downstream of and in close proximity to the dam.	It has never been repaired or maintained until now
7	N/R	5	600	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	2008
8	1969	2.5	350	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	It has never been repaired or maintained until now
9	1986	2	300	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	2007
10	1964	3	1000	Irrigation and drainage for Tan Moc commune	High because many dwellings are located downstream of and in close proximity to the dam.	N/R

**Note:** N/R = Not recorded

**Source** Records were provided by dam managers G2.1, G2.2, G2.3 and local authority G3.3

All ten dams surveyed are in critical need of repair and maintenance (see Tables 4 and 5 for details of problems at the ten dams surveyed in Tan Moc commune; and Figures 3 to 6 for typical problems).

**Table 4 Problems that exist with the ten small dams surveyed in Tan Moc commune**

Dam No.	Height (m)	Storage capacity (ML)	Hazard rating	Main problems associated with dam safety	Acceptable or Unacceptable*
1	4	600	High because many dwellings are located downstream of and in close proximity to the dam.	Excessive vegetation on the upstream face, downstream face and crest of the dam. The crest is uneven. Upstream and downstream faces are substantially eroded. Spillway is concrete and in good condition.	Unacceptable
2	6	800	High because many dwellings are located downstream of and in close proximity to the dam.	The top crest is damaged by traffic: dip on the crest. Slide on the upstream face. Excessive vegetation on the downstream face. Traffic damage and slide on the downstream. Spillway is in good condition.	Unacceptable

3	4	500	High because many dwellings are located downstream of and in close proximity to the dam.	The top crest is damaged by traffic: dip on the crest. Slide on both the upstream and downstream faces of the dam. Spillway is in good condition. Excessive vegetation and trees.	Unacceptable
4	5	500	High because many dwellings are located downstream of and in close proximity to the dam.	The top crest is damaged by traffic. Traffic damage on the downstream face. Slide on both the downstream and upstream faces. The crest is uneven. Two large holes on the top (serious). A lot of cracking on the top. Low area on the top. Spillway is appropriate.	Unacceptable
5	6	2500	High because many dwellings are located downstream of and in close proximity to the dam.	Failed in 2008, about 20 houses flooded away. Cracking on the crest. Slide on both the upstream and downstream faces of the dam. Animal burrows. Spillway is in good condition.	Unacceptable

6	5	2000	High because many dwellings are located downstream of and in close proximity to the dam.	Dams No. 5 and 6 caused a cumulative failure in 2008. Cracking. Excessive vegetation and trees on both downstream and upstream faces. Spillway is appropriately designed and built of concrete.	Unacceptable
7	5	600	High because many dwellings are located downstream of and in close proximity to the dam.	Slide and cut on the top. Small and very old outlet. Cracking. Crest is uneven. There are a number of large trees. There is no spillway.	Unacceptable
8	2.5	350	High because many dwellings are located downstream of and in close proximity to the dam.	The top is damaged by traffic. The crest is uneven, low areas on the top. Large hole on the crest. Slide. Small outlet and very small spillway (under-standard). Spillway is blocked by large trees.	Unacceptable
9	2	300	High because many dwellings are located downstream of and in close proximity to the dam.	Failed in 2008 and repaired in 2009. Rice fields were damaged because of the failure in 2008. Slide. Cracking. The top is damaged by traffic.	Unacceptable

10	3	1000	High because many dwellings are located downstream of and in close proximity to the dam.	The top is damaged by the traffic. Uneven crest and low areas on the top. Slide on the downstream. Excessive vegetation on both the downstream and upstream. Outlet is broken, very old and cracking. Spillway is too small and blocked.	Unacceptable
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**Note:** \* Based on a dam inspection checklist developed from Ministry of Environment, Lands and Parks - Water Management Branch, British Columbia (1998) "Inspection & maintenance of dams - dam safety guidelines" and Department of Sustainability and Environment, the Victoria Government (2007) "Your dam - your responsibility: a guide to managing the safety of farm dams".

**Table 5 Current physical safety problems associated with the ten dams surveyed**

Dam components	Actual problems	Details of problems	% of dams*
Reservoir	Inability to store design water capacity	Sediment accumulation Irrigation gate leakage Spillway leakage	100%
Crest	Overtopping	Inaccurate estimation of hydrographical parameters Spillway is blocked Flooding is over the design flood capacity The top is constructed lower than designed	60%
	Settlement on the crest	Traffic damage Animal burrowing activities Instability of the embankment	80%
	Transverse cracking	The dam foundation is depressed Instability of the embankment Shrinkage of surface materials Materials are low quality	20%
	Longitudinal cracking	Water in the reservoir increases or decreases suddenly. This sudden change of water level creates depression on the top The dam foundation is depressed Slide occurs on the embankment	40%

	Ruts along the crest	Traffic damage The movement of foundation	30%
Upstream slope	Seepage under the foundation	The quality of material is low. Hence, water is eroding the material Rodent activity Geological assessment is inaccurate	20%
	Slide and slump	The lack or loss of embankment material Rodent activity Erosion Traffic damage Downstream slope is too steep	80%
	Sinkholes	The movement of foundation create holes Material is seeped Animal burrows	20%
Downstream slope	Seepage through the embankment	Rodent activity creates open pathway th embankment The abutment is not properly designed and constructed	70%
	Seepage at the abutment	The abutment is not properly designed and constructed Plants/trees are not removed completely in construction	30%
	Slide and slump	The lack of or loss of embankment material Rodent activity The downstream slope is too steep	80%
Spillway	Eroded spillway	Erosion The gradient of the channel is too steep	20%
	Blocked spillway	Soil and stone erosion Trees and plants Inaccurate design	50%
Outlet	Eroded outlet	Outlet is too small Conduit is eroded Foundation movement	20%
	Leaking and breaking	Valve is broken Vandalism Outlet is too old	40%

**Note:** \* On the basis of ten dams

In summary, the small dams surveyed in Tan Moc commune, Luc Ngan district, Bac Giang province in Vietnam are now in seriously deficient condition and in critical need of upgrades and maintenance. The current condition and associated maintenance levels of the sample dams are extremely poor and unacceptable.

**Dam No.1**



**Figure 3** Excessive vegetation and trees on both the upstream and downstream slopes

**Dam No.2**



**Figure 4** Severe traffic damage on the crest

Dam No.6



Figure 5 Inability to store design water capacity because of leakage

Dam No.8



Figure 6 Piping failures resulting from construction or material defects and inappropriately designed spillway

#### 4.2 Results for Research Question 2: Factors contributing to small dam safety problems in Vietnam

According to the stakeholders interviewed most dam failures in the past coincided with the occurrence of weather extremes, especially floods and heavy rains (see Table 6). The majority of the participants interviewed believed that floods and heavy rains make a considerable contribution to dam failures in many rural provinces in Vietnam. In addition, landslide is seen as another cause of dam failures particularly in the northern mountainous provinces such as Tay Bac, Hoa Binh and Ha Giang provinces. The age of dams is also a main objective factor causing dams to fail. The stakeholder interviews and on-site surveys confirmed that dams built over 30 years ago during the Vietnam War appear to have enormous safety problems. The safety of these dams is inherently compromised because of inadequate design and construction.

**Table 6 Objective factors contributing to current dam safety problems**

Objective factors	Number of participants	Percentage of participants*
Flood	15	100%
Heavy rain	12	80%
Age of dams	12	80%
Landslide	11	73%

**Note:** \* On the basis of fifteen participants

The stakeholders expressed the view that subjective (human) factors are undoubtedly the dominant cause of the current poor dam safety status and dam failures (see Table 7). In general, human factors are seen by the key stakeholders as important or as more important for dam safety than the impacts of natural extremes and the age of dams. There are a number of human factors involved. The first two factors indicate the lack of responsibility and accountability that has a direct and strong influence on the safety of dams. The stakeholders reported that no specific organisations and individuals have taken responsibility for dam failures in the past. In addition, there is a lack of organisations and individuals that actually take responsibility at a number of stages such as dam repair, review, surveillance and maintenance as well as the setting of safety standards. Poorly defined and implemented accountability at both the central and local levels leads to the dam safety problems arising in various ways.

**Table 7 Human factors contributing to current dam safety problems**

Factors	Number of participants	Percentage of participants
Lack of responsibility	6	40%
Lack of accountability	3	20%
The absence of dam safety risk based assessment	13	86%
Poor dam safety management at the local (micro) level	12	80%
Poor dam safety management and assurance policy at the central (macro) level	6	40%
Life is given a low value	5	33%

Note: \* On the basis of fifteen participants.

The lack of dam safety risk based assessment was regarded unanimously (86%) as a contributing reason for the small dam safety problems. Most participants did not correctly identify dam safety risks and hazards from dam failures. Most of them did not understand basic concepts of dam safety risks and dam hazards. On the one hand, the explanation of the participants indicated that a large number of dams are currently at 'High' risk of failure and many dams are potentially hazardous. On the other, most of the stakeholders insisted that small dams only constitute low threats. This unawareness and ignorance of the key stakeholders about safety risks and dam hazards and the absence of risk based assessment guidelines undoubtedly has a significant contribution to the physical dam safety problems.

**Table 8 Factors related to dam safety management at the local level**

ID/ Item	Problems of dam safety management at the local level	No. of participants	% of participants*
1	Lack of adequate operation manuals and management guidelines for dam managers	12	80%
2	Dam planning is poorly conducted	9	60%
3	Dam design is poorly conducted	7	47%
4	Dam construction is poorly conducted	8	53%
5	Review and inspection are poorly conducted	5	33%
6	Remedial actions and upgrades are poorly conducted	5	33%
7	Surveillance and maintenance are poorly conducted	6	40%
8	Lack of training and education for dam managers	12	80%

9	Lack of funds and insufficient investment in local dam safety management	14	93%
10	Limited powers of local authorities, local dam managers and the local community	8	53%
11	Lack of education and preparedness for the local community	5	33%

Note: \* On the basis of fifteen participants

A majority of the participants (80%) regarded poor dam safety management at the local level as an influential factor (see Table 7). The stakeholders identified that six main problems (and a number of sub-problems) associated with the key components of dam safety management at the local level cause dam safety deficiencies (see Table 8). They include (1) a lack of adequate operation manuals and management guidelines for dam managers (item 1 in Table 8); (2) many stages including dam planning, design and construction; operation and review; monitoring and surveillance; and remedial works and maintenance are poorly implemented (items 2 to 7 in Table 8); (3) dam managers lack knowledge and qualifications to operate and manage dams (item 8 in Table 8); (4) there are insufficient funds for different stages of dam safety management (item 9 in Table 8); (5) local authorities and dam managers have insufficient financial and legal powers to handle non-complying and emergency situations. In addition, the local community has no or little influence on other stakeholders such as policy regulators, local authorities and dam managers to improve the current dam safety status (item 10 in Table 8); and (6) the local community lacks education about dam safety problems and preparedness for dam safety emergencies (item 11 in Table 8).

Poor dam safety management and assurance policy at the central level is also seen by the stakeholders interviewed to contribute to current dam safety problems (see Table 7). The results from the stakeholder interviews and comparative analysis are presented in Table 9 and indicate that the existing laws and regulations are neither efficient nor effective. In addition the current regulatory agencies at both the central and local levels lack competence in addressing dam safety problems. Moreover, the participants pointed out that the absence of dam safety assurance programs and the lack of dam safety standards are also causes of the current problems. The reported shortcomings of dam safety management and assurance policy at the central level represent a low level of involvement of central government agencies that inevitably leads to the current safety problems.

**Table 9 Factors related to dam safety management problems at the central level**

ID	Problems of dam safety management at the central level	Number of participants	Percentage of participants*
1	Incompetence of the regulatory agencies	4	26%
2	Deficiencies of the laws and regulations	3	20%
3	Lack of national dam safety programs	5	33%
4	Lack of dam safety standards	5	33%

**Note:** \* On the basis of fifteen participants

Unconsciously devaluing the lives of the local community was highlighted as being an important reason for the current dam safety problems (see Table 7). Life is given a low value and consequently the protection of the local community against hazardous dams is given little priority. Some participants pointed out that economic values and political interests are seen as more important than human life and social values. Consider the following comments:

Small dam safety management in Vietnam can be summarised briefly as no one cares, no one manages or maintains, and no one researches.... No one cares because if they fail, no one would lose their positions.... these dams are non political dams (Policy Regulator 1).

Small dams do not receive attention from government agencies, local authority, national research institutions and international organisations in Vietnam because there is a lack of economic benefits and political interests arising from this issue (Researcher 1).

In summary, the results of small dam safety management in the area examined in Vietnam include two findings in line with two primary research questions. First, the most prevalent dam safety problems are erosion, seepage, structural cracking, inability to store design water capacity because of silting and leakage, vandalism, insufficient spillway capability because of inadequate design and/or blockage, traffic damage, settlement, sinkholes, animal burrowing and excessive vegetation. Second, both objective (natural) and subjective (human) factors are major reasons for current dam safety deficiencies. Objective factors are the age of dams and natural extremes, namely flood, heavy rain and landslide. Subjective factors include (1) the lack of responsibility and accountability at both the central and local levels; (2) the lack of dam safety risk based assessment; (3) the lack of adequate operation manuals and management guidelines for dam managers; (4) improper implementation of many stages of on-site

dam safety management practices such as planning, design, construction, review, inspection, surveillance and maintenance; (5) the lack of training and education for dam managers; (6) the lack of funds and under investment in local dam safety management; (7) limited powers of local authorities and dam managers; (8) the lack of education and preparedness for the local community; (9) incompetence of regulatory agencies; (10) deficiencies of laws and regulations; (11) the lack of national dam safety programs; (12) the absence of dam safety standards and (13) the lives of the local community having a low value assumed by policy makers, government staff and local authorities.

## **5. Conclusions**

The paper has investigated the physical signs of problems associated with small dam safety in Vietnam, and explored factors contributing to the current dam safety problems in this country. The findings provide strong evidence that small dams in the study area - Tan Moc commune, Luc Ngan district, Bac Giang province constitute destructive threats to the downstream community, property and environment. As a result, there appears to be an urgent need for the Vietnamese government to take specific actions to protect lives, property and environment of downstream communities against hazardous dams. These actions are to develop appropriate guidelines and introduce an adequate accountability and assurance policy for the operation and management of small dams.

The outcomes of this research demonstrate that Vietnamese small dam safety management is completely unregulated. In addition, the role of small dam safety management was perceived as being insignificant by a number of the key stakeholders including central government agencies, local authorities and national research institutions, local dam safety management associations and the local community. The evidence provided ascertains that even though dam failures in rural provinces in Vietnam would coincide with natural phenomena, human factors are certainly the major cause of disasters resulting from these dam safety problems including dam failures.

The results provided suggest that the importance of small dam safety management should not be underestimated. On the contrary, greater attention should be paid to this issue. This research reaffirmed a concern arising through prior research that if dams are not managed properly, then all dams, large and small, high and low hazard, pose considerable safety risks because of the potential for failure either at the individual and/or cumulative level within catchments.

It is also evident that the safety of dams can be only achieved through adequate on-site practices at the local level and proper assurance policy at the central level. At the local level, the safety of dams can be achieved when various stages such as design, construction, operation, review, inspection, surveillance, remedial works and maintenance are properly implemented. At the central level, the safety of dams can be assured when the government establishes comprehensive dam safety assurance programs based on properly developed legislation.

There appears to be a need for adequate risk based assessment, responsibility and accountability policies for small dam safety management in Vietnam, and related to this need, it also appears important for the Vietnamese government to place a higher value on lives, property and the environment of downstream communities. Future research can explore how such accountability and assurance policies can best be provided in Vietnam.

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