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DAM REHABILITATION AND SAFETY IMPROVEMENT PROJECT IN VIETNAM

L. SPASIC-GRIL
Chairperson of the Dam Safety Panel of Experts, Arup, London, UK

DR. T. SY HO
Vice Chairperson of the Dam Safety Panel of Experts, Thuyloi University, Vietnam

ABSTRACT

With over 7,000 dams of different types and sizes Vietnam has a complex and evolving institutional framework for dam safety. There are more than 750 large dams, with the number of small dams estimated to be more than 6,000.

The Government of Vietnam has established a sectorial program for dam safety in recognition of the importance of securing the foundations for sustained and secure economic growth. The program was first launched in 2003, revised in 2009 and again revised in 2015, as part of the effort to revitalize the program activities and targets. Based on information available from Ministry of Agriculture and Rural Development (MARD), there are about 1,150 irrigation dams in need of urgent rehabilitation or upgrading until 2022. The program is currently being led by MARD Central Project Office (CPO), in collaboration with the Ministry of Industry and Trade (MoIT), the Ministry of Natural Resources and Environment and Provincial authorities with budget support from the national Government.

The Dam Rehabilitation and Safety Improvement Project (DRSIP) is designed to improve the safety of the dams and related works, as well as the safety of people and socio-economic infrastructure of the downstream communities. The project will also support Government to ensure a more holistic, basin level integrated development planning to improve institutional coordination, future development and operational safety. The DRSIP objectives are to provide a mix of both structural and non-structural measures to selected dams. Structural measures include the physical rehabilitation and upgrading safety work of existing dams and appurtenant structures, including instrumentation and associated dam safety plans. Such physical works represent the largest part of the project budget (>80%).

Structural measures have been proposed for 442 dams in 34 provinces. These dams were identified through an iterative, consultative prioritization process with the national authorities and provincial agencies.

The paper describes the main findings based on inspection and rehabilitation of about 20 dams currently evaluated by the International Dam Safety Panel of Experts.

1. DRSIP OBJECTIVES

The DRSIP objectives are to provide a mix of both structural and non-structural measures to selected dams.

Structural measures include the physical rehabilitation and upgrading safety work of existing dams and appurtenant structures, including instrumentation and associated dam safety plans. Such physical works represent the largest part of the project budget (>80%).

Structural measures have been initially proposed for 442 dams in 34 provinces, see Figure 1.1 below. These dams were identified through an iterative, consultative prioritization process with the national authorities and provincial agencies. The majority of those identified during preparation are classified as small dams, with 71% being less than 15m in height and with storage less than 3 MCM (see Section 4 below for classification). Ten provinces account for 50% of all dams. There is a total of 104 dams >15m in height. Large dams are found in 29 of the 34 provinces, with 50% of all large dams found in the eight provinces. 39 dams have storage in excess of 3MCM. The majority of the dams for which data exists were constructed more than 15 years ago, with 50 percent constructed between 1970 and 1990.

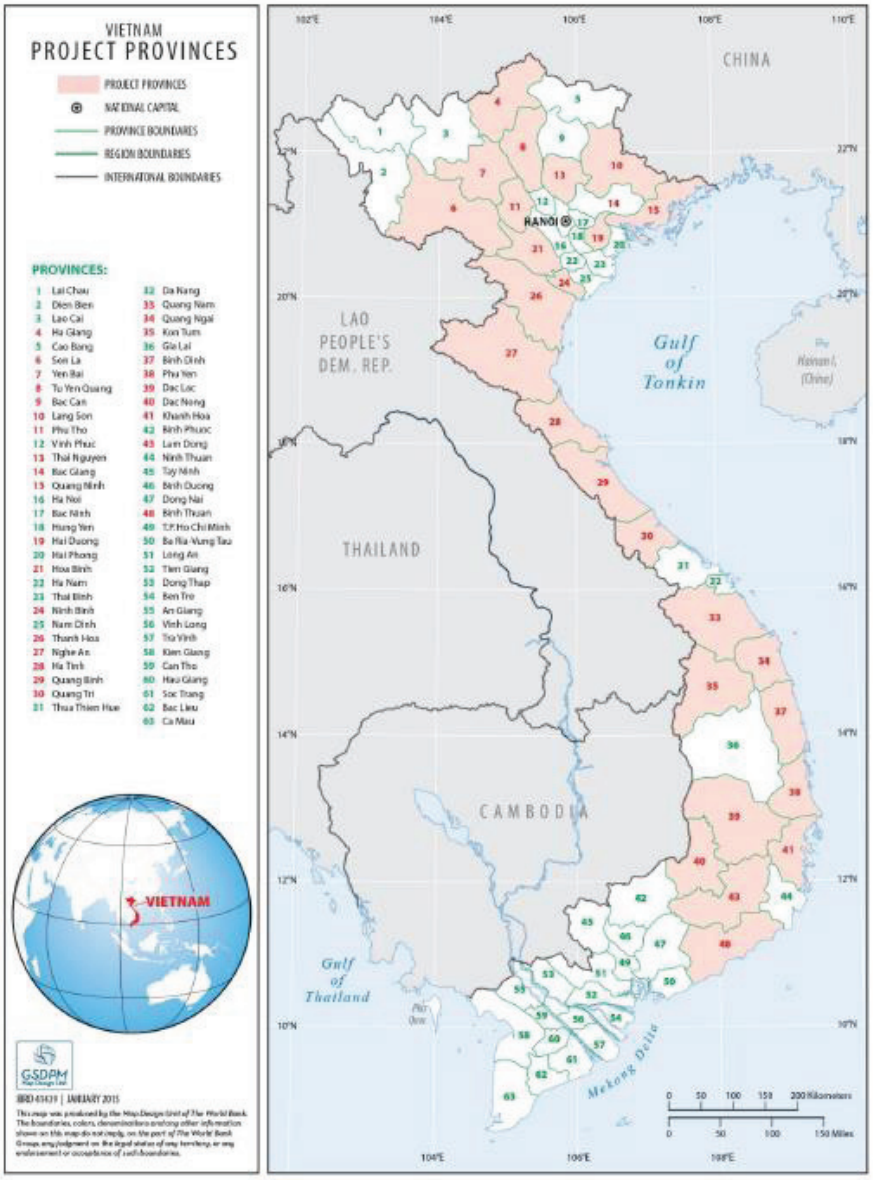

Figure 1.1 : DRSIP Project – Map of Provinces where dams are located

Non-structural interventions have been proposed to support a range of national institutional and regulatory measures, as well as pilot specific basin level measures. These basin level measures are aimed at integrating dam and reservoir operations, improving data collection and information management within the basin context and facilitating specific coordination and governance mechanisms between sectors within the provinces as well as between provinces to introduce a more holistic, long-term approach.

The project budget is estimated to US$ 443 Million; 93.3% of the budget is provided by the World Bank (WB) credit (93.3%) with 6.7% of the project budget is co-funded by the counterparts' funds. The credit agreement with the WB was signed on 8 April 2016, with a closing date 30 June 2022.

2. DRSIP COMPONENTS

The following are the DRSIP components:

Component 1 : Dam Rehabilitation (US$ 412 million). It is expected that 442 priority irrigation dams with reservoir capacity of more than 0.2 MCM and design grade from Grade IV to Special (Dau Tieng reservoir) will be rehabilitated. Large dams will be supported with Emergency Preparedness Plans (EPPs) and Operation & Maintenance (O&M) plans. In addition, the component shall support development of safeguards including: Environmental and Social Impact Assessment (ESIA), Resettlement Action Plan (RAP), Ethnic Minorities Development Plan (EMDP) to minimize negative impacts during project implementation.

Component 2 : Dam Safety Management (US$ 20 million). The component directly supports MARD, MoIT and MoNRE through implementation of non-structural measures, completion of legal framework, improvement of policies and proposal of sanctions for implementation. It also supports implementation of the model for 1 to 2 basins on integration

of dam safety management with disaster management through implementation of regulations on institutions, policies, hydromet system equipment and information, information sharing mechanism between management agencies and dam owners and coordination practice of inter-reservoir operation in the basins. Development of reservoir management model with community participation and appropriate financial mechanism towards sustainability in investment. The component also provides support for monitoring and technical assistance of line agencies, management agencies and DSPE as required by the WB.

Component 3 : Project Management (US$ 11 million). This component supports financial provision for project management, audit (independent and financial statement), and technical assistance for project implementation. There are 4 provinces that have never participated in Official Development Assistance (ODA) projects, 13 provinces that are implementing for the first time and 17 provinces (50%) that are experienced in implementing ODA projects, therefore the component shall spend a part of the budget for strengthening capacity of management units through training activities, workshops and study tours.

3. DRSIP COMPONENT 1

Under this component 442 priority dams will be rehabilitated through 34 Provincial Project Management Units (PPMUs) and MARD. The Component 1 includes the following programme:

Phase 1 :

- Includes 12 first - year priority subprojects from 11 Provinces, and
- Around 250 subprojects for the following years

Phase 2 :

- The remaining subprojects

Out of 12 first - year priority dams, seven are classified as Large Dams. Also, only for one subproject, namely Song Quao Dam (Large Dam) in Binh Thuan province (see section 7 below), has been funded by the WB; the remaining 11 first-year subprojects have been funded by the counterpart funds.

4. PROJECT OPERATION MANUAL

Prior to commencement of the project a Project Operation Manual (POM) was prepared. The POM provides classification of dams and requirements for different dam. The POM also refers to applicable guidelines and standards that need to be applied for dam safety reviews. Requirements from the POM relevant for dam safety review are summarised below.

4.1 Classification of Dams

The POM defines Large Dams by combining requirements of WB OP 4.37 and Vietnamese standards, as follows:

Large Dams are:

- H>15m
- 10m<H<15m, Storage > 3 million m3
- 10m<H<15m, Crest length > 500m
- 10m<H<15m, Spillway capacity > 2000 m3/s
- 10m<H<15m, with special design complexities (e.g., large flood handling requirements, location in zone of high seismicity, retention of toxic materials) and a large number of people at risk in downstream area,
- H<10m if they are expected to become large dams during operation

Small Dams are:

- Dams below the aforementioned thresholds of large dams (which means normally H< 15 m), and subject to OP/BP4.01(Environmental Impact Assessment). This category includes, for example, farm ponds, local silt retention dams, and low embankment tanks.

4.2 Choice of Design and Check Floods

The POM recommends the following:

- Use Vietnamese Standards (see Table 4.1 below);
- Use POM (see Table 4.2 below).

1. Dam Design Grade in accordance with the Vietnamese Standards

Table 4.1 : Recommended Design and Check Floods - Vietnamese Standards

Frequency of Flood	Design grade				
	Special	I	II	III	IV
- Design flood frequency (%)	0.10	0.50	1.00	1.50	2.00
- Year return period (year)	1000	200	100	67	50
- Check flood frequency (%)	0.02	0.10	0.20	0.50	1.0
- Year return period (year)	5000	1000	500	200	100

As it can be seen from Table 4.1, a maximum Check Flood has a return period of 1 in 5,000 years, for the Special Design Grade dam.

Table 4.2 : Recommended Check Floods - as per POM

The number of households in the downstream (household)	Extreme flood frequency
> 10,000	PMF
1,000 ÷ 10,000	0.01% ÷ PMF
25 ÷ 1,000	0.01%
< 25	0.1%

As it can be seen from Table 4.2, a maximum Check Flood could vary from 1 in 1,000 years to the Probable Maximum Flood (PMF), depending on the downstream population at risk.

4.3 Specific Actions for Large and Small Dams

The following are the recommendations (as per OP 4.37) for Large Dams and High Hazard Dams in the POM:

- Prepare and submit a Dam Safety Report (DSR);
- DSPE to review dam safety conditions;
- Appoint Design Consultant for Rehabilitation and Dam Safety Improvement Works;
- Prepare Construction Supervision & Quality Assurance Plan (i.e. CSQA Plan);
- Prepare O&M Plan;
- Prepare Emergency Preparedness Plan (EPP).

For Small dams:

- Generic dam safety measures designed by qualified engineers;
- A Dam Safety Inspection Report (DSIR) to be prepared and reviewed by the DSPE;
- For small dams, the need for a simple O&M and an EPP should be reviewed;
- For dams above about 10m in height with significant downstream hazard a simple O&M documentation to be in place and an EPP in a simplified manner.

The POM details what needs to be done during Design, Implementation and O&M phases. It provides contents that inspection, reservoir operation documents would need to include. Contents of Dam Safety Report for large and small dams are also provided in the POM. For large dams' contents

Roles and responsibilities of the various entities are also defined in the POM.

5. DAM SAFETY PANEL OF EXPERTS

The Dam Safety Panel of Experts (DSPE) has been established by the Client to provide independent review and recommendations to the Client for ensuring that safety issues of the DRSIP to be financed by the WB are adequately addressed in terms of design, construction, operation and maintenance as required by the Dam Safety Safeguard Policy (OP4.37) of the WB and GoV.

The DSPE was established in February/March 2017 and it is to be maintained throughout the project implementation phase and even the first period of operation phase. The DSPE comprises three International and four National Experts; the authors of this paper, namely Ljiljana Spasic-Gril and Dr. Tam Sy Ho are the Chairperson of the DSPE and the Vice Chair respectively.

Since establishment, the International DSPE visited 19 dams during visits in 2018 and 2019 and reviewed design documentation related to these dams. The National DSPE accompanied the International DSPE during the visits, and also reviewed documentation for 321 dams (70 Large Dams and 251 Small Dams) and visited some of the dams. The visits of the International DSPE focused on the dams that are considered by the Client and the WB to be the most complicated for the rehabilitation.

6. FIRST MISSION BY THE DSPE AND SUMMARY OF MAIN FINDINGS

During the first mission in October 2018 the DSPE visited and reviewed design documents for five selected dams. One dam, Phu Vinh Dam (Classified as a Large Dam), h=27m, V=22.5Mm^3 L=1776m, is one of the 12 first - year priority dams. Other four dams visited are from Phase 1of the project, with three dams being the Large Dams.

A summary of the main findings related to the design/review process, documents reviewed, and the dams inspected is presented below:

1. First-year priority dams: Phu Vinh Dam was visited by the DSPE during this mission; the most significant comments on the design were related to the choice of the Design and Check Flood and spillway capacity to discharge these floods, and the available freeboard. The original Check Flood was 431m^3/s, while, in accordance with the POM, the Check Flood should be $Q_{0.01\%}$ = 1770m^3/s. The DSPE stated that the Design and Check Floods were significantly underestimated, and the current design was not adequate. It was recommended to:
   - Urgently set up a procedure for the reservoir operation prior to the floods in order to provide sufficient flood routing capacity for the Check Flood;
   - Estimate households at risk downstream of the dam – initial estimate should be carried out by using the rapid method from the Guidelines to confirm the number of households at risk and the Check Flood to be used; check capacity of spillway and freeboard for the Check Flood; study feasible options for provision of the additional spillway capacity or storage to meet the flood requirements and implement the best option;
2. For the other four dams visited the following are the main recommendations:
   - Confirm the Check Flood based on the d/s hazard, adequacy of the spillway capacity and freeboard for the Check Flood; and if necessary, implement structural measures (but also see the following bullet point)
   - Check dispersive property by a combination of methods (Crumb, Pinhole, Double hydrometer and chemical); provide appropriate stabilization method by lime or gypsum and/or a combination of geotextile filter and stone pitching for the d/s slope;
3 As the current Vietnamese Guideline for the Seismic Design only defines accelerations for 1 in 475 year return period earthquakes, it is recommended to undertake seismic assessments of Large Dams in accordance with requirements of ICOLD Bulletin 148, i.e. check the dams for an OBE and SEE earthquakes; these assessments shall also include checks for susceptibility of the fill and foundation material to liquefaction, as for some dams fill material is largely composed of silty sand;
4 The DSPE is concerned about the capacity of the local Consultants to undertake the PMF estimates, dam break and seismic analysis. A possible training should be arranged in these fields; the training can be delivered by the DSPE members (National and International);

7. SECOND MISSION BY THE DSPE AND SUMMARY OF MAIN FINDINGS

During the second mission in October 2019 the DSPE visited 14 dams; nine dams are classified as Large Dams and five are classified as Small Dams in accordance with the POM.

Two dams from the first-year priority dams, namely Song Quao Dam (Large Dam) and Phu Vinh Dam (Large Dam), were visited. For these dams rehabilitation works are ongoing. Phu Vinh Dam was also visited during the first mission and was re-visited during the second mission to check implementation of the DSPE's recommendations.

Dau Tieng Dam in the Tay Ninh Province (Large Dam) has also been included in the second DSPE's mission. This dam has been classified as a Special Class Dam in accordance to the Vietnamese Standards; the dam is the largest irrigation dam in Vietnam that supplies water to more than 100,000ha of farmland, but it also supplies water for industrial and domestic use in Ho Chi Min City. The dam was commissioned in 1985. It has an average height of 28m, volume of 1,500Mm^3 and the crest length of 28,100m. The Check Flood in accordance with the Vietnamese standard is 1 in 5,000 years flood estimated to be 2,836m^3/s; however, the Feasibility Studies are currently being undertaken and the PMF has been estimated to be around 3,250m^3/s.

A summary of the key recommendations in the interest of safety, related to the dams inspected during the mission are presented below:

1. A large number of dams visited will have either the existing spillway widened or modified into a labyrinth weir, or a completely new emergency spillway proposed/ being constructed. Figure 7.1 below shows an emergency spillway just been constructed at Phu Vinh Dam (as recommended by the DSPE during the first mission). Figure 7.2 below shows a widened spillway at Khe Che Dam, which was very nearly overtopped during the 1995 flood. This clearly indicates insufficient spillway capacity for Design and Check Floods, which were originally estimated by the Vietnamese standards;
2. Song Quao Dam, a Large Dam in Binh Thuan Province: this dam was constructed in 1980s and it comprises two main dams (left & right embankments), three saddle dams (No.1-3), gated spillway and irrigation intake. The

reservoir volume is 81Mm^3 and the maximum height of the main dams is 40m. The original Check Flood, estimated based on the Vietnamese standards, was 1,153m3/s and the Check Flood estimated in accordance with the POM, is 1,358m^3/s. In order to provide an additional flood discharge outlet, an emergency spillway is to be constructed. However, although the main rehabilitation works are under way, the works on emergency spillway have not started yet because of the land take issues with the Forestry Department. The DSPE recommended that this situation is resolved as soon as possible; it is recommended that the contractor prepares a plan of emergency measures for the situation when the rehabilitation works are ongoing and there is no emergency spillway in place;

Figure 7.1 : Newly constructed emergency spillway at Phu Vinh Dam

Figure 7.2 : Khe Che Dam: the existing spillway has been widened (the white line shows the side wall of the original spillway)

3. Dau Tieng Dam, the largest irrigation dam in Vietnam: the DSPE recommended that the PMF estimates are checked as they appear low; also, the bathymetric survey has never been done for this reservoir which was commissioned in 1985 – the DSPE strongly recommended that this survey is done so that height/storage curves for the reservoir could be updated; all the current flood capacity calculations are based on the original storage figures and largely vary; it is known that sand was mined from the reservoir, therefore sedimentation is clearly an issue;
4. For many dams visited seepage through the dam body, foundation or both was an issue. A typical anti-seepage measures proposed are a grouting wall. However, for many dams reviewed, the wall does not penetrate sufficiently into impermeable strata and will need to be deepened;
5. For homogeneous embankments that were constructed of dispersive soils need to ensure that testing is done for dispersion potential of the new embankment fill;
6. No monitoring instrumentation was envisaged for dams that are classified as Grade III and IV in accordance to the Vietnamese standards - the Panel recommends that a water level measurement gauge and a “V” notch weir at the lowest point of the drain at the d/s toe are provided as a minimum.

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