Asset Management Guideline for Irrigation Facilities in Viet Nam

(Summary)

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Agricultural Development Consultants Association of Japan (ADCA)

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1. Outline of asset management in irrigation sector

Asset management (AM) in irrigation sector is defined as project management to provide good irrigation services sustainably based on the role of irrigation projects in response to social needs. AM is composed of systematic activities to maintain the functions of irrigation facilities (assets) within various constraints, albeit detailed work and actions of AM are not defined. The core component of AM is stock management (management of physical facilities). AM includes fund management and human resource management in addition to stock management. This manual focuses on stock management of irrigation facilities in Southeast Asia.

The AM process for irrigation facilities focusing on stock management is as follows.

(1) Daily check and repair of facilities by local engineer in charge
(2) Regular function diagnosis by regional engineer
(3) Prediction of deterioration based on diagnosis results, comparison of countermeasures, formulation of function maintenance plan
(4) Facility monitoring based on facility monitoring plan
(5) Implementation of countermeasures based on the function maintenance plan and monitoring results
(6) Accumulation of data on survey and examination results as well as results of countermeasure work

Function diagnosis results are usually divided into five soundness levels according to the degree of deterioration: that is, S-5 for no countermeasure required, S-4 for observation required, S-3 for small-scale repair / reinforcement, S-2 for medium-scale repair / reinforcement, and S-1 for renewal. The facilities are classified into three levels based on the importance of the facility: that is, A for high, B for medium, and C for low importance.

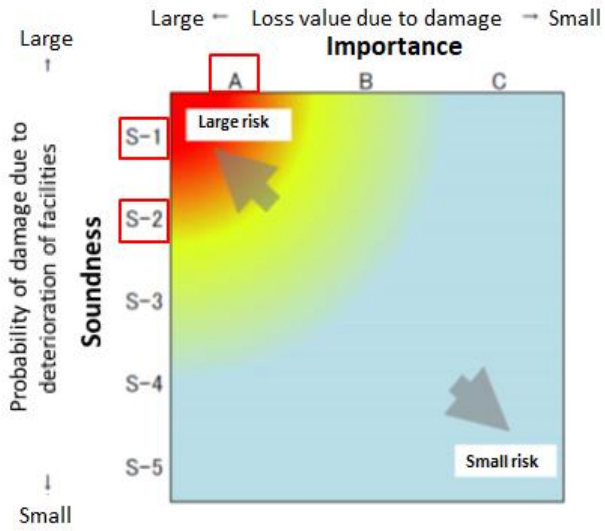


Figure 1.1 Conceptual diagram of risk analysis

The irrigation stock management database system accumulates information on irrigation and drainage facility specifications, maintenance and repair history, and function diagnosis results etc. as a system to provide a centralized understanding of facility conditions and to support appropriate function maintenance measures.

Based on the digitized data base, decision makers can decide budget allocation appropriately according to the priority which will be set by soundness and importance evaluation accumulated in the data base. If the domestic resources for repair / reinforcement / rehabilitation / renewal is insufficient, foreign resources should be requested based on the digitized data base through due procedures, in order to avoid function breakdown of irrigation system. The digitized data base will provide an objective material quite useful for explanation to external stakeholders.

2. Function diagnosis

2.1 Survey team

The field survey for function diagnosis is conducted by forming a team. The standard survey team consists of three irrigation engineers (leader 1, assistant 2) and two workers. It is desirable that the workers are members of a water user's association (or water user's group). The minimum number of a team is 2 irrigation engineers (1 leader, 1 assistant) and 1 worker, 3 in total.

Member	Roles
Leader (Irrigation engineer)	・ Guidance to team members on how to implement asset management work ・ Creation of a survey and work schedule ・ Identification of deteriorated points / parts in a field ・ Data entry to AM System with a smartphone, and photo taking ・ Checking the data to have been entered in a simplified survey form by an assistant
Assistant 1 (Irrigation engineer)	・ Engineer in charge of the target irrigation project ・ Support for the leader by indicating deteriorated points / parts ・ Explanation to the leader the past repair history to deteriorated points / parts ・ Record additional data and photographing
Assistant 2 (Irrigation engineer)	・ Engineer in charge of a certain area of the irrigation project who knows the site well ・ Support for the leader by indicating deteriorated points / parts in the area ・ Measurement of deformed points / parts (photographing)
Worker 1	・ Member of a water user's association (or water user's group) in the irrigation project. ・ Support for the leader by indicating deteriorated points / parts in the area ・ Support for the measurement of deformed points / parts
Worker 2	・ Local worker or member of a water user's association (or water user's group) ・ Support for the measurement of deformed points / parts

Table 2.1.1 Members and roles of a survey team

Facility	Irrigation	Gate making / metal processing	Electricity	Pump	Engine	Measuring device for water level, weather, etc.	Remarks
Earth dam	◎	○	○			○	
Important concrete structure	◎	○	○			○	Dam intake facility, spillway, headworks, diversion, etc.
Important metal gate	○	◎	○			○	
Canal / pipeline	◎	○				○	
Pump station	○	○	◎	◎	◎	◎	

Note) ◎: Required, ○: Participation as needed

Table 2.1.2 Engineers required for on-site functional diagnosis for each irrigation facility

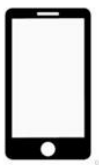
				
Smartphone	Steel tape (Convex)	Tape measure	Crack scale	Test hammer

Fig 2.1.1 Field survey instruments

Other materials including a field note (field survey forms), writing utensils (ballpoint pen), red spray to indicate the deteriorated part, etc. are carried in a bag together with measuring instrument.

2.2 Earth dam

Earth dam is composed of dam body (embankment), concrete structures (spillway, water intake, conduit, etc.), and metal gates. Here shows survey on dam body (embankment) only, and the others are described in the section of important concrete structures, important metal gate, and canal.

Function diagnosis survey on earth dam is divided into three types: (i) survey on deformation of the dam body,

The field survey method for the earth dam is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the upstream slope, crest, downstream slope, right bank / left bank of the natural ground. To make it possible to determine the condition of the surface of the dam, weeding should be done before the survey, or the survey should be conducted during the dry season when the slope surface has dried up.
- If there is any deformation, it should be referred to the Table 2.2.1 and the soundness and importance should be entered to the AM System (Chapter 3) using a smartphone. It is unnecessary to fill in S-4 and S-5 because they do not need to be repaired.
- The details of the deformation should be entered in the "Memo" column of the AM System as an objective basis for the soundness. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column. Since there is no character limit in the "Memo" field, any information can be filled.
- In the AM System, coordinates and names of points are automatically set when points are registered. However, since proper names are not set in the automated point names, it becomes difficult to identify the points when tabulated. Therefore, the point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system. When taking photographs, it is desirable to include 3 types such as a distant view, a near view, and measured state so that the deformed parts can be seen.

S-3: Cracks formed in longitudinal direction in asphalt pavement are visible.

S-2: Sliding has occurred due to infiltration of rainwater.

Fig2.2.1 Evaluation of cracks and sliding of embankment

2.3 Important concrete structures and Headworks

(1) Important concrete structures

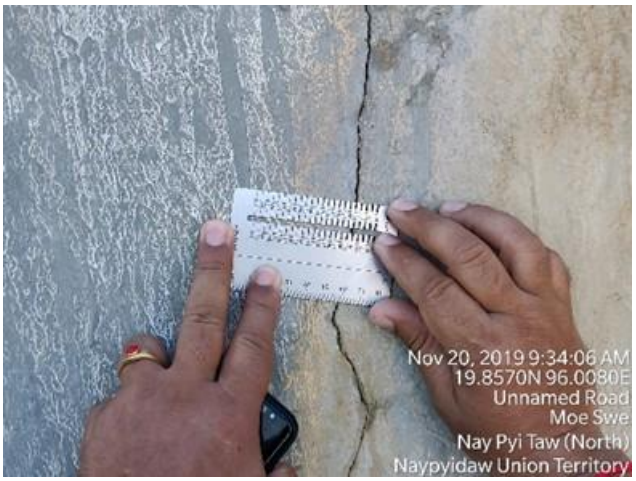
Important concrete structures are dam spillway, dam intake facility (including conduit), headworks, etc.

The deformation of concrete structures is classified into internal deterioration, which is deterioration of structure itself, and external deterioration such as deformation of structure due to external force, deformation of ground, and deterioration of joints that connect the structure each other. Internal deterioration includes (i) crack, (ii) peeling, (iii) precipitates, and (iv) abrasion. External deterioration includes (i) structural damage, (ii) ground deformation, (iii) joint deterioration, (iv) water seepage, and (v) scouring. The deterioration is subject to soundness assessment.

The field survey method for important concrete structures is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the structures to the extent possible. It should be noted not to enter dangerous areas. Deformation in dangerous areas will be photographed remotely using drones, etc.
- If there is any deformation, it should be referred to the Table 2.2.1 and the soundness and importance should be entered to the AM System using a smartphone. It is unnecessary to fill in S-4 and S-5.
- The details of the deformation should be entered in the "Memo" column of the AM System as an objective basis for the soundness. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column.
- The point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system.

S-3: Cracks and rust juice are generated. Evaluation Progressive change is not observed in previous years and necessary to continue monitoring.



S-3 to S-2: Maximum crack width is 1.0mm or more

Fig2.3.1 Evaluation of cracks

(2) Headworks

Headworks consists of intake, weir, ancillary facilities, and management facilities.

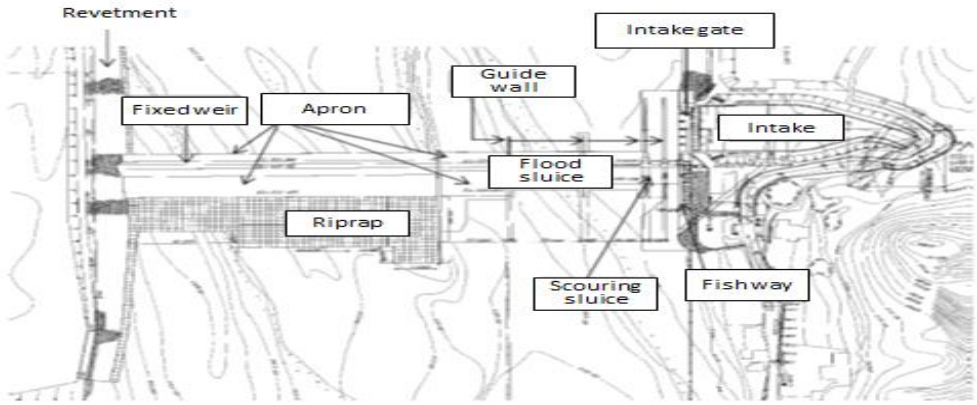


Fig 2.3.2 Standard facilities of headworks

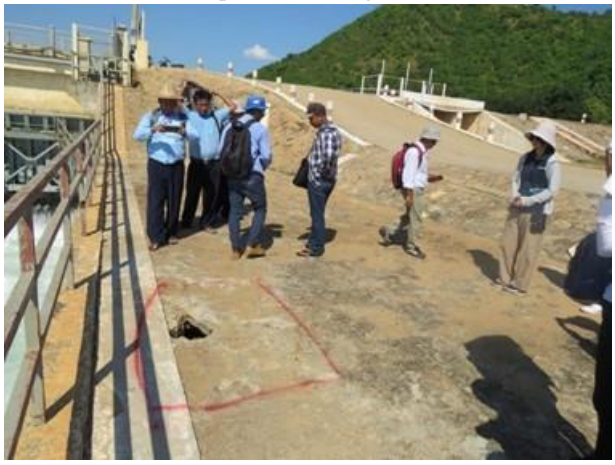
Concrete facility

- Existence and extent (range) of surface deterioration such as cracks in concrete facility
- Deformation and inclination of weir pillars (estimate from concrete joint, opening of gate attachments, steps, etc.)
- Abrasion and breakage of weir body and apron
- Deformation, subsidence and flushing-out of riverbed bricks
- Abnormal fluctuation of riverbed (scouring, sedimentation, etc.)
- Deterioration of revetment (deformation, subsidence, loss, etc.)
- When setting a fixed point by dividing components of headworks, it is necessary to select a location that represents the component (a location where deterioration feature looks like standard) and a location where deformation is significant.

Machinery (gate equipment)

- Observe entire facility by visual inspection, and roughly grasp the presence / absence and details / extent of deterioration.
- Survey surrounding environment such as water quality to understand the cause of deterioration.
- Prior to site survey, it should be confirmed that locations of invisible part, necessity of temporary works, possibility to use power necessary for operation check, and the suitable period of diagnosis work.

S-1: A headworks is seriously eroded by running water



S-3 : Hollowing behind the retaining wall

Fig2.3.3 Evaluation of earth dams (embankment)

2.4 Important metal gate

Important metal gate is installed in dam, head works, check gate, etc. The function diagnosis survey of machinery (gate) is performed by visual inspection, palpation, sound listening, simple measurement such as vibration measurement, gate operation confirmation, etc. to find the presence of abnormality.

Parts of metal gate to be diagnosed are divided into beam (BM), board (BD), frame (FR), and spindle (SP). The deformation of gate is classified into deterioration of painting, deflection, corrosion, deterioration of watertight rubber, deterioration of welded parts, abrasion, deterioration of the spindle, etc. This deterioration is subject to soundness assessment.

The field survey method for important metal gates is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the structures to the extent possible. It should be noted not to enter dangerous areas. Deformation in dangerous areas will be photographed remotely using drones, etc.
- If there is any deformation, it should be referred to the Table 2.2.1 and the soundness and importance should be entered to the AM System using a smartphone. It is unnecessary to fill in S-4 and S-5.
- The details of the deformation should be entered in the "Memo" column of the AM System. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column.
- The point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system.
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S-2 : Corrosion of gate body

S-3 : The lower part of the gate body where the coating film deteriorated and peeled

Peeling

Swelling

Cracking

Fig2.4.1 Evaluation of corrosion, peeling, swelling and cracking

2.5 Canal

Open canal is roughly classified by non-lined canal, brick-lined canal (including masonry canal), and concrete-lined canal (unreinforced and reinforced). Non-lined canal is supported by back soil such as natural ground and backfill soil. The stability of the canal depends on the stability of the ground which is affected by flow, drainage of surface water, rainfall, and groundwater. Brick-lined canal (including masonry canal) is sustainable rather than non-lined canal, however it is apt to deformation, tilt, and collapse often caused by water flow, subsidence of the foundation, collapse of the back ground / slope, or depression. Unreinforced concrete-lined canal maintains its

The followings are points to check when conducting visual inspection during field survey.

- Existence and extent (range) of deformation, inclination, defect, etc. (concrete)
- Existence and extent of surface deformation like cracks (concrete)
- Deformation of joints (level difference, breakage of the water stop, loss of peripheral concrete, traces of water seepage, etc. (concrete)
- Uneven subsidence and meandering
- Subsidence, depression, collapse, and flushing out of structures in canal including surrounding ground

The field survey method for canals is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the entire canals.
- If there is any deformation, it should be referred to the Table 2.2.1 and the soundness and importance should be entered to the AM System using a smartphone. It is unnecessary to fill in S-4 and S-5.
- The details of the deformation should be entered in the "Memo" column of the AM System. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column.
- The point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system.

S-3 : Sliding, erosion of non-lined

S-3 : Peeling of bricks

S-3 : Erosion, cracks of concreat

S-3 : Abrasion of gate

S-3 : Sinking of culvert

S-2 : Collapse of gate

Fig2.5.1 Evaluation of sliding, erosion, peeling, cracks

2.6 Pipeline

The mechanism of pipeline deterioration differs greatly depending on the pipe type (concrete, steel, and synthetic resin). In addition, since the pipeline and the ancillary facilities are organically combined as one system, the function of pipeline may be deteriorated depending on the deformation of the ancillary facilities and the actual operation of equipment such as water diversion valves. In the field survey, while visually grasping the state of deformation of the entire target pipeline, it should be confirmed of such as the current state of land use at the burial position, water pipe bridges, regulation tanks, air valves, etc.

The followings should be noted when conducting on-site survey.

- Presence of ground depression, collapse, and traces of water leakage
- Deformation of water pipe bridges and other exposed pipes
- Deformation of regulation tank body, other pipeline facilities, valves, etc.
- Low riverbed in siphon facility, presence of exposure
- Appearance and operation status of valves such as air valves, and status of instruments (presence of failure)
- Land use status above ground at the burial site of pipelines
- Existence of important structures and residences

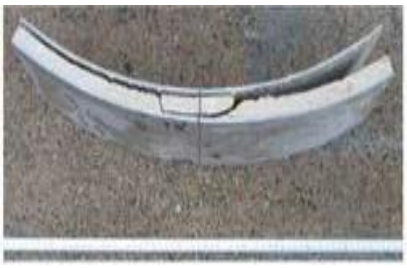
The points of the visual field survey are as follows.

- In the surrounding situation, in order to grasp the deformation of the facility from the above-ground part, check for water leaks (traces), road surface cracks, subsidence, changes in land use, etc.
- In exposed parts (water pipe bridges, exposed pipes, etc.), check for corrosion, cracks, deformation, etc. on the outer surface of pipes.
- At the ancillary facilities, check for rusting of valves, malfunction, presence of water leakage, malfunction of instruments, etc. Also, for concrete structures such as farm ponds, check for cracks, compressive strength, deformation, etc.

The field survey method for pipelines is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the entire pipelines.
- If there is any deformation, it should be referred to the Table 2.2.1 and the soundness and importance should be entered to the AM System using a smartphone. It is unnecessary to fill in S-4 and S-5.
- The details of the deformation should be entered in the "Memo" column of the AM System. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column.
- The point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system.

S-3 : Crack / defect in pipe surface (PC)



S-3 : Internal & external pressure test, and segment bending test

S-3 : Rust condition in pipes (SP)

Fig2.6.1 Evaluation of sliding, erosion, peeling, cracks

2.7 Pump station

The pumping station is composed of multiple facilities and equipment with different functions such as pump equipment, concrete structure, and house building. Here, function diagnosis of pump equipment is targeted. For the other works of pumping station, the other function diagnosis method relating to irrigation facilities are applied.

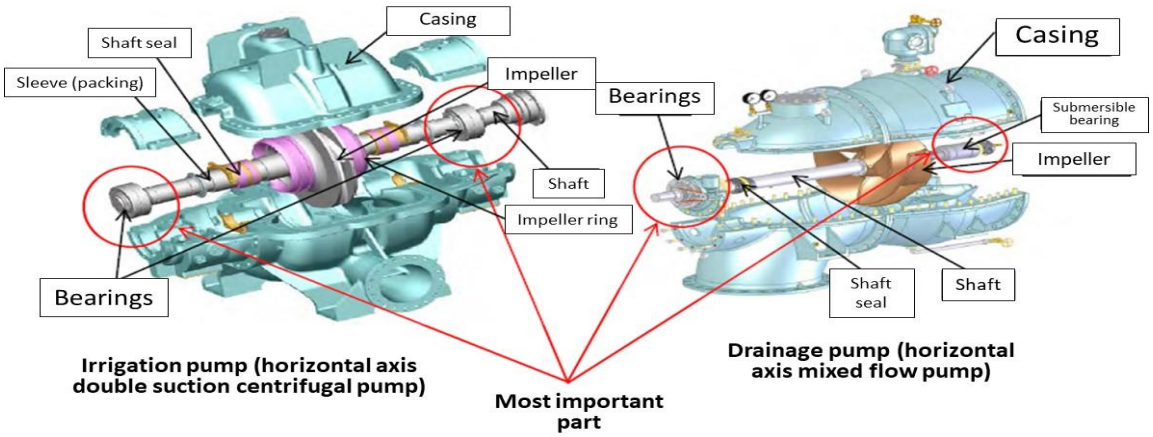


Figure 2.7.1 Pump structure

The main work of rough diagnosis survey is diagnosis of equipment status and abnormalities through checking mainly by the five human senses such as visual, tactile, and auditory senses. The work includes inspection of the indicated values of instruments attached to the equipment, measured values using simple measurement tools, the recorded data of daily or periodic inspection, maintenance or repair, and daily operation.

The field survey method for pumping stations is as follows.

- In the field survey, the presence of deformation is confirmed while surveying the entire pumping stations.
- If there is any deformation, the soundness and importance should be entered to the AM System using a smartphone.
- The details of the deformation should be entered in the "Memo" column of the AM System. If the deformation is large, it is necessary to measure the length, width, and height and add them to the "Memo" column.
- The point names must be changed to the names given to each irrigation facility so that they can be distinguished from others.
- It is necessary to take three photos of each deformed point with a smartphone, and register the photos taken to the AM system.

S-3 : Corrosion and rust on the bearings of pump motor, the lower part of shaft seal, and the foundation base

S-2 : Corrosion of pump motor bearings and shaft seal

S-3 : Corrosion and rust of pump anti-motor bearings and shaft seal

Fig2.7.2 Evaluation of corrosion, rust

3. Visualization and database building of function diagnosis results using AM System

3.1 Use of AM System

The on-site function diagnosis survey is implemented for each irrigation facility to identify deteriorated or damaged situation, and is consisted of: (i) the confirmation of location to be repaired, (ii) its deterioration status, (iii) the measurement of deformation, (iv) photo taking, etc. Since there are many defective parts in irrigation facilities that have deteriorated, it is desirable to digitize the survey results on-site as much as possible in order to survey without omission and compile them as observed records.

3.2 Outline of AM System

1. Characteristics of ADCA system

   Operate with a smartphone, Management of past data, Share data, Low software cost

2. Top pages

   Responsive display, Base map, Marker (indicator of the soundness), Site menu (GIS, AM, Link)

3. Preparation

   Devices (smartphone/tablet/laptop connected with internet, video)

4. Data entry

(1) Crick the GPS button from the GPS menu to display the current location on the map.
(2) Right crick or long press the point to be registered on the map to appear the temporary marker.
(3) The data entry form will open, so enter all the required information.
(4) If there are images or videos, select the image/video file to upload.
(5) If there are other necessary information, enter it in the [Memo] cell.
(6) After entering all the information, click the [Submit] button.
(7) Confirm the entered data.

5. Data browsing

-Click the marker or select a marker from the search menu and click [view] on the marker menu.

6. Search/PDF or Excel output

6-1 Click the search icon in the asset management menu.
6-2 If click [PDF] from the search result screen, the information of all the points of the search result is downloaded in PDF format.
6-3 If click [EXCEL] from the search result screen, the information of all the points of the search result is downloaded in Excel format,

7. Edit/Delete

7-1 Data editing
(1) Crick the marker to be edited, and click [Edit] on the menu.
(2) Use edit form.
(3) Confirm the edited contents on the “Confirm edit” screen.

7-2 Data delete
(1) Crick the marker to be deleted, and click [Edit] on the marker menu.
(2) Confirm the data to be deleted on “Delete all?” screen.

4. Function conservation plan

The function conservation plan includes deterioration prediction, priority setting for repair / reinforcement / renewal, countermeasure construction method, countermeasure implementation scenario, function conservation cost calculation, and facility monitoring plan, in addition to the results of function diagnosis. The functional conservation plan can be implemented only when it is financially supported, so the most important is the financial plan based on the results of objective functional diagnosis.

4.1 Summary

(1) Summary of the An Kim Hai Irrigation Project (in Hai Phong City under the jurisdiction of An Hai IMC)

- Purpose: approximately 5,000 ha of agricultural land by taking water from a tributary of the Red River.
- Construction period: 19**～19**
- Project cost: The total project cost is ** VND.
- Management of irrigation facilities: the An Hai IMC and the Agricultural Production Cooperatives (APC)

(2) Main irrigation facilities

- Water intake facility: Concrete structures, Steel gates, ** Mm3/ year
- Main canal: Concrete, ** m
- Lateral canals: Concrete ** m, Brick, Earth ** m
- Check gate: Concrete, Steel gate, Number of gates is ****
- Pumping station (PS): Concrete, Brick building, Horizontal shaft centrifugal pump, Number of PSs is ****

(3) Positioning of function conservation plan

Soundness		S-1			S-2			S-3		
Importance		A	B	C	A	B	C	A	B	C
Renewal	Emergency renewal	◎								
	Normal renewal		◎							
	Renewal within 5 years			◎	◎	◎	◎			
Important repair	Important emergency repair	◎	◎	◎	◎	◎				
	Important normal repair				○	○	◎			
	Important emergency repair within 5 years						○	◎	◎	◎
Regular repair	Emergency repair	○	○	○	○	○	○	◎		
	Normal repair							○	◎	◎
	Repair within 5 years								○	○

Note) Important repair is a large-scale repair that greatly exceeds the regular repair.

Table4.1.1 Positioning of function conservation plan

(4) Summary of implementation plan

S1-A	S1-B	S1-C	S2-A	S2-B	S2-C	S3-A	S3-B	S3-C	計
1	4	3	2	6	26	6	2	1	51

Table4.1.2 Implementation plan

- The implementation plan (financial plan) to be completed within 5 years based on the priority of each location after calculating the individual construction cost is as follows.

Rank	Name	Quantity	Year 1	Year 2	Year 3	Year 4	Year 5	Total
S1-A	Cống dưới đường 17B	Large culvert 70 m	300,000	600,000	600,000	500,000		2,000,000
Total	1		300,000	600,000	600,000	500,000		2,000,000

Table4.1.3 the individual construction cost (Example)

4.2 Results of function diagnosis survey

The results of function diagnosis are summarized as follows.

(1) Implementation date: January 21, 2022

(2) Surveyor: Operation and maintenance team of An Hai IMC

(3) Method

- Site reconnaissance, visual inspection, simple measurement
- Information input from smartphone to AM system
- Output to EXCEL file of the input result in the office
- Inspection, correction, addition of input information

(4) Judgment of soundness and importance

- Soundness is evaluated in the following five ranks. The data of points ranked as S1 to S3 are input to the AM system.

  S-5: Sound, S-4: Signs of deterioration, S-3: Ordinary deterioration,

  S-2: Significant deterioration (management limit level), S-1: Serious deterioration (use limit level)
- Importance is evaluated in the following three ranks. A: High Importance. B: Middle, C: Low Importance
- Based on the judgment of soundness and importance, the priority of repair/renewal locations is determined.

(5) Results of function diagnosis

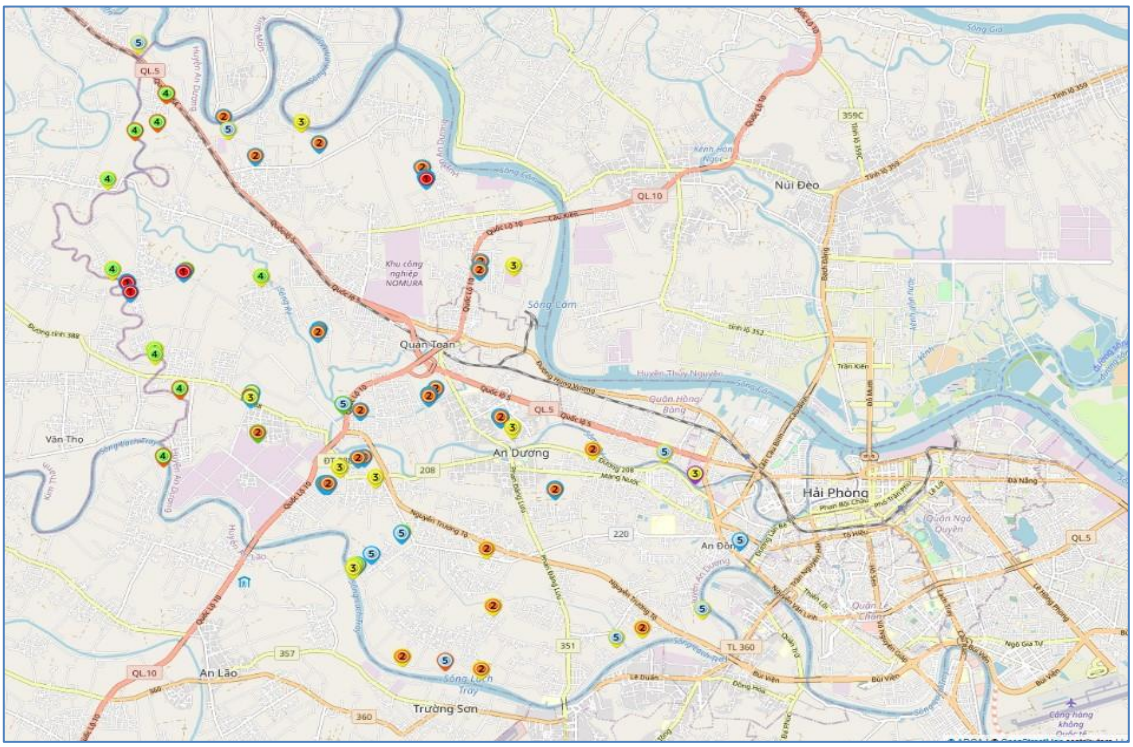


Fig4.2.1 The locations of the deterioration points

Created date	Edit date	Capital/Province	Name	Latitude	Longitude	Type	Material	Soundness	Importance	Memo	Image1	Image2	Image3
25/Jan/2022	23/Aug/2022	Hai Phong City	Cống dưới đường 17B	20.875670	106.566425	Structure	Concrete	S1	A	Cống buy khẩu độ nhỏ, đặt sâu, hở khớp nối không đảm bảo khả năng tiêu thoát nước cho kênh Hoàng Lâu. Cần nâng cấp, xây mới. Dự kiến triển khai xây dựng trong quý 4 năm 2022	 50.jpg	 51.jpg	 52.jpg

Table4.2.1 Details of the function diagnosis results for each rank (Example)

4.3 Cost calculation

The calculation method of the construction cost is as follows.

- The repair / renewal quantity for each deterioration point is estimated by simple measurement as much as possible.

- As a general, when repairing or renewing, the original shape should be restored. However, regarding the repair / renewal construction method, the most advantageous technology should be adopted based on the calculation results of the life cycle cost **(Annex 1)**.
- In order to facilitate the calculation of repair / renewal quantity and cost, standardization will be made as much as possible.
- The work unit price (labor cost, material cost, machine use cost) shall be that of *** month, *** year.
- For repair / renewal work requiring a large amount of money, several construction methods should be compared. When comparing those methods, not only cost, but also easiness of construction, possibility of material procurement, and construction period should be considered. When comparing costs, life cycle cost should be used instead of investment (capital) cost. Also, in order not to delay the start of repair / renewal work for important structures, a deterioration curve should be created to estimate the start deadline **(Annex 2)**.

Rank	Name	Memo	Repair/ Renewal	Quantity	Cost	Period (years)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
S1-A	Cống dưới đ ường 17B	Cống buy khẩu độ nhỏ, đặt sâu, hở khớp nối không đảm bảo khả năng tiêu thoát nước cho kênh Hoàng Lâu. Cần nâng cấp, xây mới. Dự kiến triển khai xây dựng trong quý 4 năm 2022	Renewal	Large culvert 70 m	2,000,000	4	300,000	600,000	600,000	500,000	0	2,000,000
Total	1				2,000,000		300,000	600,000	600,000	500,000	0	2,000,000

Rank	Name	Memo	Repair/ Renewa	Quantit y	Cost	Period (years)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
S1-B	Trạm bơm Hà Nhuận	Tường kênh bị nứt gẫy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	Repair	100 m	20,000	1	20,000	0	0	0	0	20,000
S1-B	Kênh tưới Trạm bơm Hà Nhuận	Tường kênh bị nứt gẫy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	Repair	70 m	14,000	1	14,000	0	0	0	0	14,000
S1-B	Kênh tưới Trạm bơm Hà Nhuận	Tường kênh bị nứt gẫy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	Repair	120 m	24,000	1	24,000	0	0	0	0	24,000
S1-B	Kênh tưới Trạm bơm An Hòa	Kênh tưới sau trạm bơm An Hòa bị sập đổ một bên tường kênh	Repair	90 m	18,000	1	18,000	0	0	0	0	18,000
Total	4				76,000		76,000	0	0	0	0	76,000

Table4.3.1Construction cost calculations for each degree of soundness and importance. (Example)

Soundness/ Importance	Number of points	Cost (USD)					
		Year 1	Year 2	Year 3	Year 4	Year 5	Total
S1-A	1	300,000	600,000	600,000	500,000	0	2,000,000
S1-B	4	76,000	0	0	0	0	76,000
S1-C	3	117,000	0	0	0	0	117,000
S2-A	2	123,000	0	0	0	0	123,000
S2-B	6	0	27,000	29,400	120,000	15,000	191,400
S2-C	26	0	0	0	0	536,000	536,000
S3-A	6	0	0	0	0	46,000	46,000
S3-B	2	0	0	0	0	20,000	20,000
S3-C	1	0	0	0	0	3,000	3,000
Total	51	616,000	627,000	629,400	620,000	620,000	3,112,400

Table4.3.2 Total construction cost (Example)

4.4 Budget allocation plan

The concept of the budget allocation plan is as follows.

- It is assumed that the total budget required for repair and renewal will be evenly distributed over five years.
- In order of priority, S1-A has the highest priority and S3-C has the lowest priority.
- If the budget for the first year is not secured, it will be passed on to the next year in descending order of priority.
- The five-year plan will be reviewed every fiscal year. At this time, the soundness level is changed to S4 or S5 for the point where repair/renewal is completed, and it is excluded from the AM system in the next year. When the fiscal year changes, the data of the previous fiscal year is accumulated as a database, so the data will not be erased.

Rank	Name	Memo	Year 1	Year 2	Year 3	Year 4	Year 5	Total
S1-A	Cống dưới đường 17B	Cống buy khẩu độ nhỏ, đặt sâu, hở khớp nối không đảm bảo khả năng tiêu thoát nước cho kênh Hoàng Lâu. Cần nâng cấp, xây mới. Dự kiến triển khai xây dựng trong quý 4 năm 2022	300,000	600,000	600,000	500,000	0	2,000,000
Total	1		300,000	600,000	600,000	500,000	0	2,000,000
S1-B	Trạm bơm Hà Nhuận	Tường kênh bị nứt gãy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	20,000	0	0	0	0	20,000
S1-B	Kênh tưới Trạm bơm Hà Nhuận	Tường kênh bị nứt gãy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	14,000	0	0	0	0	14,000
S1-B	Kênh tưới Trạm bơm Hà Nhuận	Tường kênh bị nứt gãy, sập đổ, hư hỏng, các thanh giằng ngang kênh bị mất.	24,000	0	0	0	0	24,000
S1-B	Kênh tưới Trạm bơm An Hòa	Kênh tưới sau trạm bơm An Hòa bị sập đổ một bên tường kênh	18,000	0	0	0	0	18,000
Total	4		76,000	0	0	0	0	76,000
S1-C	Kênh tưới Trạm bơm Thuần Tỵ	Kênh tưới sau trạm bơm Thuần Tỵ tường kênh bị nứt gãy, đổ vỡ, lớp vữa trát bị mục ruỗng, đáy kênh bị hư hỏng.	36,000	0	0	0	0	36,000
S1-C	Kênh tưới Trạm bơm Thuần Tỵ	Kênh tưới sau trạm bơm Thuần Tỵ tường kênh bị nứt gãy, sập đổ, lớp vữa trát bị mục ruỗng, đáy kênh bị hư hỏng.	27,000	0	0	0	0	27,000
S1-C	Kênh tưới Trạm bơm Thuần Tỵ	Kênh tưới sau trạm bơm Thuần Tỵ tường kênh bị nứt gãy, đổ vỡ, lớp vữa trát bị mục ruỗng, đáy kênh bị hư hỏng.	54,000	0	0	0	0	54,000
Total	3		117,000	0	0	0	0	117,000
S2-A	Đoạn đầu kênh Hoàng Lâu nhánh 2	Đoạn Kênh đất dài 1,3km, lòng kênh bị bồi lắng không đảm bảo yêu cầu tiêu thoát nước.	75,000	0	0	0	0	75,000
S2-A	Kênh trước cống Đầm Ma	Mái kè phía sông của cống Đầm Ma bị gãy nứt, hư hỏng.	48,000	0	0	0	0	48,000
Total	2		123,000	0	0	0	0	123,000

Table4.4.1Details of the five-year budget allocation plan (Example)

Annex 1 Life cycle cost

Function maintenance cost is calculated as a life cycle cost (LCC).
For irrigation facilities, a series of processes from survey, planning, design, construction, operation, maintenance, renewal and disposal is called the life cycle, and all cost required during this period is called LCC.

Canal type	Standard *1 service life	Renovation scenario		
		Description	Frequency	Cost
Concrete canal	40 years	Partial renovation	Once in 20 years	10% of the construction cost *2
Masonry canal	30 years	Complete renovation	Once in 30 years	100% of construction cost *2
Brick canal	20 years	Complete renovation	Once in 20 years	100% of construction cost *2
Earth canal	10 to 20 years	Complete renovation	Once in 15 years	100% of construction cost *2

*1 MAFF. 2017. *2 Construction cost excludes land acquisition cost. Source) JIID. 2018

Table A1.1 Service life and renovation scenario for canal type

$$LCC = CI + \sum_{t} (CM \times F_{pw} + CR \times F_{pw})$$

$$F_{pw}(t) = 1/(1+i)^t$$

Here,
LCC: Life cycle cost
CI: Initial cost (labor cost + material cost + machine operation cost + land acquisition cost)
CM: Operation and maintenance cost
CR : Renovation cost
Fpw (t): Present value coefficient (*t* annual discount coefficient) = $1/(1+i)^t$
i: Social discount rate
t: Year
* If (1 - elapsed year/useful life) < 0, then (1 - elapsed year/useful life) = 0 is used

*Excel has a following function to calculate net present value: NPV(discount rate, value 1: value n) *JIID 2018

Figure A1.1 shows the formula for calculating LCC.

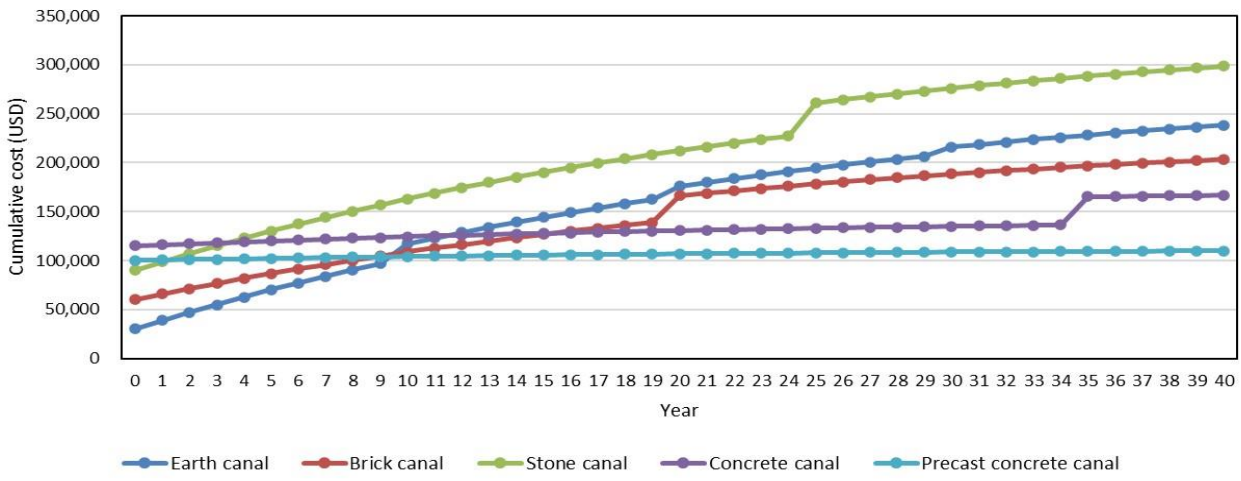


Figure A1.2 LCC comparison by channel type

Social Discount Rate (SDR)		Application
Japan	4%	Current value used in irrigation project
	0%	Japanese government bond yield (2016 - 2017)
Southeast Asia	9%	Value used by Asian Development Bank
	2.6%	Yield of government bonds in Thailand

Source) JIID. 2018.

Table A1.2 SDR in Japan and Southeast Asia

Annex 2 Deterioration prediction

Deterioration prediction is carried out for the purpose of comparing and examining the time and method of countermeasures required for each facility / equipment.

A standard deterioration curve is drawn by using the results of function diagnosis survey conducted in Japan so far (Figure A2.1). However, the data used as the basis of the curve has a large variation.

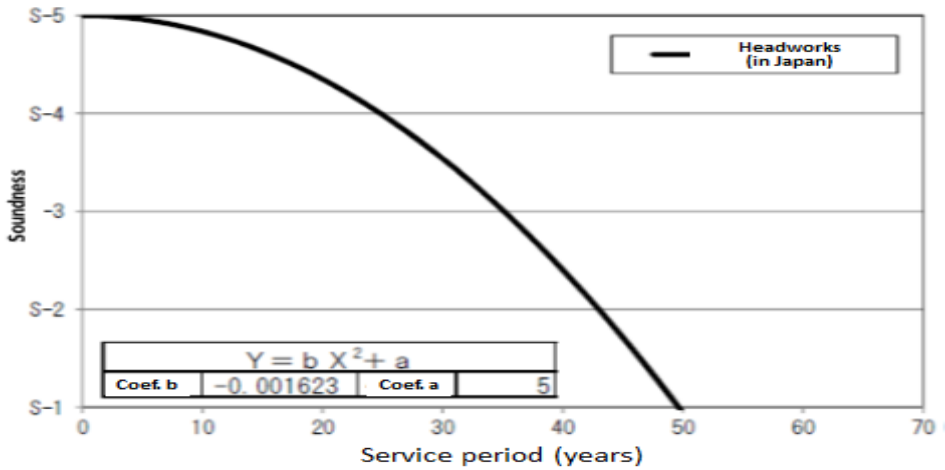
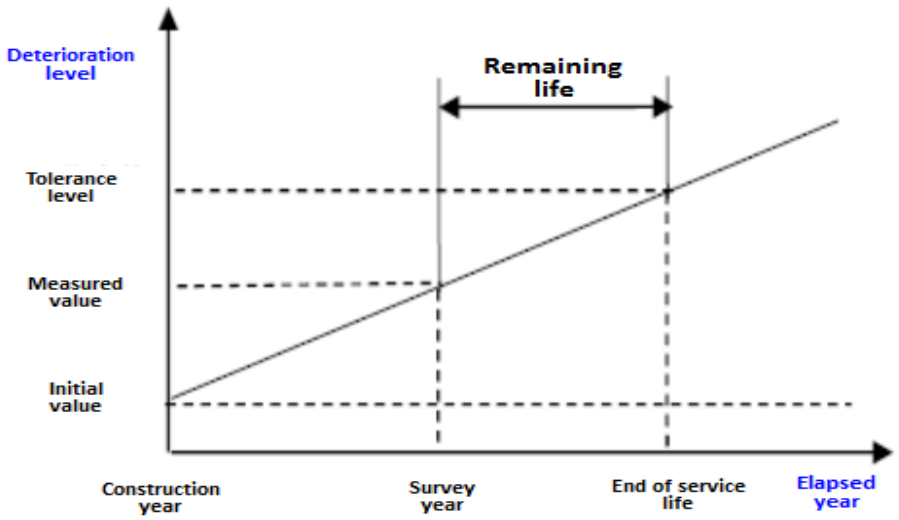


Figure A2.1 Standard deterioration curve drawn based on the data of headworks survey in state-run irrigation system in Japan

There is a method of remaining life prediction by using the results of detailed diagnosis survey for deterioration prediction of facility and equipment (metal gate, etc.) that gradually degrades over time. In this method, the progress of abrasion / corrosion amount of a surveyed site and the degree of change in the insulation resistance value is compared with an allowable value or a criterion of the facility / equipment. For example, if abrasion has progressed for 2 mm in 20 years, the remaining life is predicted to be 10 years, when the allowable value is set as 3 mm.



Note) Tolerance level: Amount of deterioration that does not affect the functionality of facility

Figure A2.2 Concept of remaining life of facility / equipment