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TECHNICAL REPORT

IRRIGATION DATABASE IMPROVEMENT FOR THE LOWER MEKONG BASIN

Vientiane, January 2018

Document History

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1	0	Proposal and draft outline of final report preparation, including background and justification, strategy, data structure and proposed methodology, and irrigation data framework and structure.	December 2012	Itaru, Prasong
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2	2	Draft QA/QC process and Metadata chapters	November 2017	Kritsana
2	3	Revised per internal comments from technical advisor and Chief of the River Basin Planner	November 2017	Chamaporn, Kritsana
2	4	Revised based on the member countries' comments	December 2017	Chamaporn
2	5	Revised based on the member countries' comments	January 2018	Chamaporn

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Abbreviations and Acronyms

AIP	Agriculture and Irrigation Programme
AIS	Agricultural and Irrigation Specialist
BDP	Basin Development Programme
CNMC	Cambodian National Mekong Committee
DARD	Provincial Department of Agriculture and Rural Development
DB	Database
DoI	Department of Irrigation
IWRM	Integrated Water Resources Management
IWRP	Institute for Water Resources Planning
IKMP	Information & Knowledge Management Programme
GIS	Geographic Information Systems
LAs	Line Agencies
LMB	Lower Mekong Basin
LNMC	Lao National Mekong Committee
MARD	Ministry of Agriculture and Rural Development
MOWRAM	Ministry of Water Resources and Meteorology
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NMCS	National Mekong Committee Secretariat
NWG	National Working Group
PD	Planning Division
PDIES	Procedures for Data and Information Exchange and Sharing
TD	Technical Support Division
TNMC	Thai National Mekong Committee
TOR	Terms of Reference
RID	Royal Irrigation Department
RSGISS	Remote Sensing and GIS Specialist
SIWRP	Southern Institute for Water Resources Planning
SP	Strategic Plan
VNMC	Viet Nam National Mekong Committee
VMD	Viet Nam Mekong Delta
QA/QC	Quality Assurance/Quality Control

Acknowledgements

The Planning Division (PD) would like to express sincerely thank the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF/Japan) for providing the funds and supporting the irrigation database improvement project in the LMB through the former Agriculture and Irrigation Programme (AIP), which is now one sector under the PD. Thanks also goes to the National Mekong Committees for organizing consultation meetings and assisting in the acquisition of data. Special thanks are due to the former Information Knowledge Management Programme (IKMP), which is now the Technical Support Division (TD), for their support on technical activities and issues for database improvement. This technical report was initially prepared by AIP's technical advisor and coordinator. The final report was then consolidated and synthesized based on contributions by the Agriculture and Irrigation Specialist (AIS) of the PD and Remote Sensing and GIS Specialist (RSGISS) of the TD. Data and information was collected and consolidated from relevant national implementing agencies, which conducted data collection, and improvements at national level were undertaken by the National Working Groups (NWGs) engaged by the National Mekong Committee Secretariat (NMCS). Before finalization, the report was reviewed and approved again by the Chief of the River Basin Planner, Director of the Planning Division, National Focal Points and Experts. A list of the project implementation units is provided in ***Table 1*** in section 1.3.

Executive summary

The improvement of the MRC Irrigation Database is a high priority among a series of activities proposed by the previous Agriculture and Irrigation Programme (AIP), which is one of 12 MRC programmes implemented during 2011–2015. The latest updated irrigation database was developed by the Basin Development Plan (BDP) in 2009 to conduct the basin-wide hydrologic scenario analyses incorporating water-use for present and planned irrigation schemes. The BDP team developed the database based on the older irrigation database of 2001 and 2004, which lacked detailed metadata. Many data items of the BDP irrigation database 2009 are strictly designed and focused for development scenario analyses and they mainly contain information to support the feasibility assessment of crop area expansion in the future. Unfortunately, there are many missing data items that should be included in a comprehensive irrigation database for further utilization. At the 2nd workshop on Improving the Irrigation Database on 10–12 September 2012 in Siem Reap, Cambodia, the Member Countries agreed on the content of the database to be upgraded and improved.

Since the end of 2012, the AIP activity 1.4.1 – Improvement of the Irrigation Database of the Lower Mekong Basin – has been implemented for the purpose of updating the basic information of individual irrigation systems into a GIS facility with better-informed irrigation planning and benefiting from easier access to such information on the actual irrigable area, maximum irrigated rice plantation areas, and total capacity of reservoirs, etc. The project's goal is to have a reliable and manageable data source on the irrigation sector and to have a versatile database that facilitates various analyses and policy proposals with specific objectives to compile a common irrigation database of the whole LMB based on existing and available datasets in the Member Countries, and build up national capacity to improve, maintain, and unitize the developed database. Four National Working Groups participated in this AIP activity, including the Lao PDR Department of Irrigation (DoI), the Royal Irrigation Department (RID) of Thailand, the Institute of Water Resources Planning (IWRP) of Viet Nam-Highlands, and the Southern Institute of Water Resources Planning (SIWRP) of Viet Nam-Delta. For Cambodia, the irrigation database has been improved through a project under the MRC Council Study by a national consultant. In this project, a comprehensive irrigation dataset of the years 2012–2015 for the whole LMB is developed based on existing irrigation databases from 2001, 2004, and 2009 with support from the previous AIP and IKMP, relevant institutions, and local government agencies in each country. The agreed data structure and information in the attributes are reviewed in Annex I.

After years of data compilation from various sources, both spatial and non-spatial data, data manipulation and quality assurance/quality control processes, the new irrigation database of the LMB has been completed including spatial maps and attribute tables for five GIS data layers of irrigation projects, existing irrigation headwork, existing irrigation area, existing irrigation reservoirs, and existing irrigation canals. However, the existing irrigation canal layer has not been completed because of limitations and difficulties in regional data collection and availability. As a consolidated irrigation database from the national data, the Lower Mekong Basin includes 6,755 irrigation projects, which can benefit 4,780,730 ha of actual irrigable area and 4,825,885 ha of estimated maximum irrigable area for rice crops planned in irrigation periods. There are 6,596 existing irrigation headworks with existing irrigated area in the wet season of 4,003,796 ha. The existing irrigation reservoirs at 1,317 locations have active total capacity and active capacity for irrigation of at least 16,448 and 11,378 million m^3, respectively (there is no capacity information in Cambodia). During project implementation, national staff participated in a capacity building programme through 11 national workshops and on-the-job training on ArcGIS software for irrigation database improvement and QA/QC methods and processes.

1. Introduction

1.1 Background and justification

The Governments of the MRC Member Countries realized the importance of agriculture and water sectors to achieve poverty reduction and food security goals in each country. During the MRC's Strategic Plan (SP) 2011–2015, the Agriculture and Irrigation Programme (AIP) was formulated to address land and water use issues in the agriculture sector to promote basin development and played an important role in providing technical support in the area of irrigation development. In the AIP document (2011–2015), an improvement of the MRC irrigation database was a priority and indicated the needs for MRC Member Countries to fill in the gaps of their national irrigation databases and create a manageable dataset, which could form a regional hub for irrigation data management and sharing.

The most recent available irrigation database at regional level was developed by the Basin Development Plan (BDP) Programme in 2009 for the purpose of basin-wide hydrologic scenario assessment of water-use at present and planned irrigation schemes. With active participation from relevant line agencies, which are Ministry of Water Resources and Meteorology (MOWRAM) of Cambodia, the Department of Irrigation (DoI) under the Ministry of Agriculture of Lao PDR, the Royal Irrigation Department (RID) of Thailand, and the Southern Institute for Water Resources Planning (SIWRP) of Vietnam, the irrigation database campaign in 2009 successfully concluded with the most recent datasets available at that time. The BDP 2009 irrigation database mainly contains information for future development plans, such as potential areas of expansion, future irrigable areas, etc., which includes parts that may not be suitable for updating and maintaining. Although it was developed based on the previous irrigation database of 2004, many of its original features were not replicated in the 2009 database. Moreover, it contains neither the spatial coverage of irrigated areas nor the major scheme layout, even though the oldest MRC irrigation database of 2001 included irrigation schemes in geographical features. The metadata needed to identify data sources or data collection methods to ensure the reliability of the contained figures was also missing. On completion, the regular update mechanism was not incorporated into any implementation plan, which meant the irrigation database was out-of-date at the regional level.

Realizing the importance of updating the irrigation database of the Lower Mekong Basin, as well as the benefits of networking national line agencies in maintaining the updated datasets, the AIP initiated an activity to update irrigation datasets for the whole LMB and develop a data updating mechanism for both national and regional levels. Out of a total 23 AIP activities, the AIP activity 1.4.1 – Improvement of the irrigation database – has been one of the top priority activities to be implemented during the MRC SP 2011–2015. Towards the end of the work agreements, only three Member Countries, Lao PDR, Thailand, and Viet Nam (Highlands and Delta), decided to participate in AIP activity 1.4.1. At the same time, Cambodia joined the project through the study on impact assessment of mainstream hydropower projects ("The Council Study") resulting from verbal discussions at the 18th council meeting of the MRC. Irrigation is one out of the six main thematic sectors of infrastructure and water-use identified for the study. Therefore, updating the irrigation database in Cambodia can fulfill the required establishment of a comprehensive irrigation database for the whole LMB.

The project aims to produce basic information of individual irrigation systems into a GIS-based database and support better informed irrigation planning benefiting from easier access

to information on current land-use and future land-use plans, soil characteristics, geology, topographic conditions, and socio economics, etc. In this project, a new comprehensive irrigation dataset has been developed based on the existing irrigation databases of 2001, 2004, and 2009 with support from the relevant institutions and agencies of the Member Countries. This project also provides National and Provincial staff with capacity building to manipulate, analyze and update the data using the most updated GIS software. This updated and improved irrigation database will facilitate the following analysis:

- Impact of climate change or dam construction on the water demand and availability at each irrigation system: locations of the command area and intake point, meteorology maps, such as annual precipitation map, etc.
- Potential areas for further irrigation development: possibility to soil map, general topography map, DEM and flood maps, river networks, land-use and road network maps, existing and planned irrigated area maps, meteorology maps, such as annual precipitation maps, etc.
- Recurrent cost analysis: total project costs, general features of each major structure, year of construction, current condition of facilities, etc.
- Irrigation efficiency and potential for improvement: efficiency figures or intake volume in design and potential determinants of irrigation efficiency which includes state of canal lining and drainage systems, type of control structures and water allocation systems, field application methods, soil types and geology, irrigation scheduling and farmers' participation, etc.
- Potential of crop diversification: canal features and existence of reservoir and possibility to layer roads and market access maps, soil maps, meteorology maps, groundwater productivity maps, etc.
- Fish migration: location of irrigation headworks, type and height of headworks, existence of fish ways, fish habitat maps, etc.

Due to the budget constraints and restructuring of the MRCS, this project has been delayed and some of the facilitation goals cannot be fulfilled due to the limitation on data availability in the MCs. Under MRC's Strategic Plan 2016 – 2020, to finalize the improvement of the irrigation database has been conducted under task 3.10.1.4 – Finalize irrigation database improvement – which was led by the Planning Division and supported by the Technical Support Division. The outputs from the project on irrigation database improvement will be used to support the MRC Data and Information System under the Procedures for Data and Information Exchange and Sharing (PDIES).

1.2 Objective of the activity

The goals of this project are to develop a reliable and manageable data source on the irrigation sector and to have a versatile database that facilitates various analyses and policy proposals. This project aims at improving the irrigation database at both national and regional levels. The specific objectives are as follows:

To compile a common irrigation database of the whole LMB based on existing and available datasets in the Member Countries;

To build up national capacity to improve, maintain, and unitize the developed database.

1.3 Summary of activity implementation

At the first Steering Committee Meeting organized in Ha Noi, Viet Nam on May 15th, 2012, the improvement of irrigation database (pervious activity#1.4.1, current activity #3.10.1) was identified as one of the eight priority activities that needed to be immediately implemented. In order to facilitate the implementation of the activity, the MRC Secretariat organized a preparatory study and a number of consultation meetings at both national and regional levels. On July 12th, 2012, the 1st regional consultation workshop was held in Udon Thani, Thailand, in which the detailed project proposal was presented by the AIP team. The participants from the Member Countries also had an opportunity to discuss and comment on the draft proposal. The discussion covered a wide range of important topics related to irrigation database improvement, such as objectives of the project, basic design of the irrigation database, the structure of the database, national working groups, responsible line agencies, etc. After having completed the 1st regional consultation workshop, a revised version of the draft proposal (version 18 July 2012) was circulated to NMCs and concerned line agencies for further comment and was finalized at the 2nd regional consultation workshop as agreed during the first workshop. During 10–12 September 2012, the 2nd Regional Consultation Workshop was organized in Siem Reap, Cambodia to finalize the proposal and reach agreement on the mandatory lists, detailed item descriptions, and rules and conditions for the irrigation database. The workshop facilitated agreement on the data field table including all the essential issues.

A) Organizing personnel for project implementation

At the beginning of 2013, the implementing agencies of the four Member Countries took part in the activity 1.4.1: irrigation database improvement activity through Work Agreements between MRCS and NMCS. Later, Cambodia decided to resign from activity 1.4.1 but fortunately joined the irrigation database improvement project through the Irrigation Thematic Area of the Council Study. Therefore, the irrigation database was completed by the four Member Countries. The lists of main personnel/organizations for the project are shown in ***Table 1***

Table 1: Main personnel and organizations involved in the irrigation database improvement

No	Name	Position	Organization
Cambodia			
1	Mr. Sao Samphear	National Consultant	
Lao PDR: Department of Irrigation (DoI)			
2	Mr. Nouandeng Rajavong	Deputy Director of DoI as Project supervision	DoI
3	Mr. Pasonexay Insisiengmay	Deputy Director of Planning and Cooperation Division as Team Leader	Planning and Cooperation Division, DoI
4	Mr. Vongsakda Vonxay	Deputy Director of Science and Technology Center as Deputy Team Leader	Science and Technology Center, DoI

No	Name	Position	Organization
5	Mrs. Keomany Thanasack	Technical Official as Member	Irrigation Development and Drainage Division, DoI
6	Mr. Sengdavanh Inthavong	Technical Official as Member	Irrigation Operation and Maintenance Division, DoI
Thailand: Royal Irrigation Department (RID)			
7	6 personnel		RID Headquarter
8	4 personnel		Regional Irrigation Office 4, 5, 6, and 7 of RID
Viet Nam-Highlands: Institute of Water Resources Planning (IWRP)			
9	Thai Gia Khanh	Deputy Director of IWRP as team leader and general management	IWRP
10	Tran Quoc Uy	Senior expert for QA/QC Database	Planning Division of the Southern Central and Highland Region, IWRP
Viet Nam-Mekong Delta: Southern Institute for Water Resources Planning (SIWRP)			
11	Nghiem Dinh Thanh	Team leader, General management	SIWRP
12	Tran Quang Tho	Technical Official for GIS-collection and data update	

B) The implementation process

At national level

- Organize national consultation workshops to review the project proposal and ToR and form the national working teams.
- Organize a team meeting to follow up working progress and discuss problems.
- Organize national capacity building (in-house training and workshops, field trips, on-the-job training) on irrigation database improvement utilizing GIS technology and QA/QC process.
- Review the existing database and available data and information of MRC and the national organizations.
- Check and validate the previous irrigation database
- Add new records to the given datasets
- Organize field surveys
- Update irrigation database in accordance with the new data structure
- Conduct QA/QC process of national irrigation database before submitting to MRCS
- Prepare the national reports including proposing a concrete plan to maintain, regularly update and share with MRCS, and utilize the new database and implementation plan for necessary national capacity building.

- Revise the new national irrigation databases and reports based on MRCS comments, then finalize and submit to produce the regional irrigation database and report.

At regional level

- Prepare the project proposal, Terms of Reference, working guidance, database structure design, report outline and format.
- Organize regional consultation workshops for Member Countries to share and agree on the project goal and objectives, road map, implementation plan, and other details.
- Follow up and provide support to the national working teams on technical issues, working progress and plans.
- Overview and manage the overall financial issues of the project.
- Regularly communicate, report, and consult on the progress and constraints of project implementation to the donor: the Ministry of Agriculture, Forestry, and Fisheries of Japan.
- Review national irrigation databases and reports and provide feedback and comments for improvement to the national consultant/working groups.
- Conduct 1st and 2nd round of QA/QC process before combining and producing the regional irrigation database.
- Produce the regional irrigation database.
- Prepare the regional report.
- Finalize the project for irrigation database improvement.

1.4 Structure of the report

The report consists of 12 parts and with the main content for each part as follows:

Part 1 introduces an overview of the initiative of irrigation database improvement, objectives of the project, and a summary of the activity implementation process.

Part 2 is a summary of the field of Agriculture and Irrigation in the Member Countries of the LMB, representing its characteristics related to the preparation of the regional database of the LMB.

Part 3 introduces the content of the new database structure that include the attribute spatial and attribute table data.

Part 4 introduces the methodology of project implementation, analysis, and processing of data, along with methods to control the data for ensuring the quality and quantity of data. The method of training for building capacity in member countries is also mentioned in this section.

Part 5 is the main content of this report. This section details the entire process for updating and improving the irrigation database, starting from the description of the review process and inheritance of the existing data from the MRC 2001, 2004 and 2009. This part mentions data collected from these sources in the relevant agencies and provinces to supplement the irrigation data and describes in detail the implementation process for updating the new datasets.

Part 6 is the summary description of the status of the irrigation system. The description consists of spatial data, attribute data and the links between them. The links between the spatial and attribute data form a summary description of irrigation data for each province in the Member Countries of the LMB.

Part 7 describes the content on processing QA/QC for data and the results of the QA/QC process.

Part 8 describes metadata of the irrigation database of the LMB.

Part 9 reviews the results of implementation on capacity building for the National Working Group and project members in each Member Country of the LMB.

Part 10 is the content related to the proposed workplan and arrangements to maintain the database and share data with the MRCS.

Part 11 is the content relating to financial aspects of the project.

Part 12 is the conclusion and recommendations.

2. Overview of the Agriculture and Irrigation Sectors in the Study Area

2.1 Overview of the study area

The study area covers the whole Lower Mekong Basin (LMB) with the total area of approximately 606,000 km^2. The Lower Mekong Basin covers 86 percent of Cambodia, 97 percent of Lao PDR, 36 percent of Thailand and 20 percent of Viet Nam, and contains four physiographic regions – Northern Highlands, Khorat Plateau, Tonle Sap Basin, and the Mekong Delta. (Snidvongs and Teng, 2006; MRC, 2010)

Northern Highlands

The Northern Highlands forms the upland region of northern Thailand and northern Lao PDR. The Mekong River Basin here is characterized by high mountains with several peaks rising to over 2,000 meters and valley floors more than 600 meters below the mountain crests. In this region, the Mekong is constrained in steep-sided bedrock cut channels. The tributary network in this area has large tributaries entering the Mekong's left (Nam Ta, Nam Ou, Nam Soung and Nam Khan) and right (Nam Mae Kok and Nam Mae Ing) banks. These tributary networks mostly flow through steep-sided rock-cut valleys. However, in places the tributaries broaden and develop floodplains (MRC, 2010; Kityuttachai et al, 2016).

Khorat Plateau

The Khorat Plateau is a saucer-shaped basin perched at an elevation of about 300 meters above sea level. The plateau is bound to the west and northwest by the Loei – Petchabun foldbelt, and by the Annamite Mountains to the east and northeast. To the south the cuesta forms a low ridge that sits above the Tonle Sap Basin. The only significant internal topographic feature is a low range of hills (Phu Phan uplift) that cut across the basin trending from the NNW to SSE. This low range divides the Khorat Plateau into two sub-basins, the Sakhon Nakhon/ Savannakhet Basin to the north, and the Mun/Chi Basin to the south. The tributaries on the right bank of the Mekong (Songkhram and Mun), which flow across the low-gradient and low-relief central region of the Khorat Plateau, have well developed dendritic architecture. In contrast, the tributaries on the left bank of the river (Nam Ca Dinh, Se Bang Fai and Se Bang Hiang) fall steeply from sources high in the Annamites. (MRC, 2010).

Tonle Sap Basin

The Tonle Sap Basin is a large dome like structure that has been 'unroofed' through erosion, leaving a rim of hills standing above the alluvial plains that fill the center of the basin. The Mekong enters the basin just north of Pakse and flows through a broad valley flanked by the southern rim of the Khorat escarpment to the west and the Boloven Plateau to the east. At the southern end of this stretch the mainstream breaks up into a complex network of branching and reconnecting channels. The Mekong drops into the alluvial plain of Cambodia through a series of cataracts at Khone Falls. The river then flows southwards along the eastern margin of the basin in a section of branching channels until Kratie. Here, the course of the mainstream takes a right-angled turn westwards as the river is deflected by extensive basaltic lava flows that form the upland area north of Ho Chi Minh City. The tributary network entering the left bank of the Mekong in this stretch of the river is dominated by the catchments of the Se Song, Se San, and Sre Pok (3S basin). The western and central part of the Tonle Sap Basin forms a

low-gradient and low-relief landscape in which sits the Great Lake, its extensive floodplain and the network of tributaries that feed into the lake. The Tonle Sap is the largest lake in Southeast Asia, serving as a natural reservoir, storing flood waters from the surrounding watersheds, and regulating river flows in the dry period, consequently helping to relieve droughts in southern Cambodia and the Mekong Delta (MRC, 2003).

The Mekong Delta

The top of the Mekong Delta is defined near Phnom Penh where the largest distributary river channel, the Bassac River, splits from the mainstream. South of Phnom Penh, the delta rapidly expands to form a wedge-shaped delta plain that covers an area of 62,520 km2 (Nguyen et al. 2000). The modern delta has two major distributary channels, the Mekong and Bassac Rivers, which split into a number of smaller channels to form the Nine Dragons, as the mouths of the Mekong are collectively known.

The climatic feature of the Lower Mekong Basin is known as tropical monsoonal regime, which is classified by a highly seasonal rainfall pattern due to a winter/summer reversal of airflow. The climate is almost permanently hot and seasonally extremely moist, with a minimum average monthly temperature not less than 20°C. The combination of two monsoon regimes is the fundamental driver of the Mekong hydroclimate. The Southwest monsoon, which is the dominant climatic feature, occurs during the northern hemisphere summer when temperature differences between the land and the Indian Ocean force moisture laden air to precipitate over the Mekong's mountains. The southwest monsoon divides the calendar year into the wet (May – October/November) and the dry (November/December – late April) seasons. The northeast Monsoon, originating in the Pacific Ocean, contributes minimal and unpredictable precipitation and carries lower temperatures to Viet Nam to the east of the Central Highlands, which provide a rain shadow effect over the Mekong Basin. Due to the tropical climatic feature in the LMB, most natural vegetation type is dominated by deciduous dipterocarp forest or Central Indo China dry forest in Thailand, within the Mekong tributaries of central and southern Lao PDR, on the plains of northern, eastern and south-central Cambodia and in the upper Se San and Sre Pok Basins in Viet Nam. (MRC, 2010; MRC, 2014)

About 65 million people live in the Lower Mekong Basin, according to the national population statistics of the four LMB countries. Cambodia and Lao PDR largely place within the basin but together include only 30 percent of the basin population. Thailand and Viet Nam comprise about 39 and 31 percent of the basin's population, respectively. About 80% of the basin's population still lives in rural areas and more than 70 ethnic groups live in the Mekong region, most of them practicing subsistence agriculture in upland regions. The population growth rate is annually around 1.2% on average (UN, 2010; MRC, 2016). Cambodia and Lao PDR have population growth rates above the mean for the LMB countries, but the fertility rates have fallen below the world average in recent years. In Viet Nam, available data show modest natural growth rates. In Thailand, some provinces have negative population growth rates, indicating low fertility rates and out-migration. By 2060, the total population is projected to reach approximately 83 million, 20% higher than the current population. By 2060 between 50% and 70% of the people in Thailand, Vietnam, and Lao PDR, and 35% in Cambodia, are expected to live in cities (MRC, 2016). Agriculture is still a major economic activity in the LMB. More than 10 million hectares of the LMB's total arable land is used for rice cultivation. Economic crops, including coffee, cassava, soybean, and sugarcane, are commonly cultivated in all countries. Para-rubber plantation is rapidly promoted that affect the changing of the

landscape throughout the region. In upland areas, shifting cultivation to produce hill rice, maize, and other subsistence crops remains. In Cambodia, Lao PDR and the Mekong Delta of Viet Nam, the river supports major rural economies of the local people as it provides sustenance of livelihoods for millions of fishers and farmers (MRC, 2010, 2014, 2016).

2.2 Agriculture

Agriculture is the most significant activity that provides livelihoods for major populations in the Lower Mekong Basin, being dominated by rain-fed rice cultivation in Cambodia, Lao PDR, Northeast Thailand and the Central highlands of Viet Nam, and irrigated rice in parts of the Mekong Delta of Viet Nam. The monoculture cropping system of rice has been mainly exploited and cultivated since the 18th Century in a fertile floodplain among the mountainous areas in the north of Laos and the north of Thailand. And since the 19th century, the expansion of large-scale rice cultivation has been promoted in vast fertile floodplains of northeast Thailand and the Mekong Delta in Cambodia and prominently in Viet Nam. More than 10 million hectares of the agricultural land in the LMB are used for rice production. It covers more than 80 percent of the agricultural output for all four Member Countries. The majority of rice production is consumed by people in country, but Thailand and Viet Nam also exported to the global market (MRC, 2010; MRC, 2017).

In ***Cambodia***, rice production has slowly increased in both area and yield since the early 1990s due to ongoing post-war rehabilitation and infrastructure reconstruction. Between 2007 and 2014, rice production increased from 2.6 tons/ha to 3.1 tons/ha in 2014 or approximately by 2.2 % per year on average because the Ministry of Agriculture, Forestry, and Fishery (MAFF) of Cambodia has provided agricultural extension to individual farmers through policies, improving varieties and seed quality, and enhancing production methods and cropping techniques. In ***Lao PDR***, rice is also a dominant crop, grown during the wet season in lowlands in the central and south regions and southern uplands (MRC, 2017). Between 1985 and 2013, the rain-fed rice production in Lao PDR notably increased from 1 million tons to almost 2.7 million tons. For ***Thailand***, most areas in the LMB are covered by paddy fields; around 80 percent in the northeastern region. The three main rice cropping systems are: lower paddy land – planted annually with rice in the wet season and faces risk of flooding and temporary waterlogging; middle paddy land – the most productive, with better water control and reduced flood risk; and upper paddy land – planted (if at all) to drought-resistant, short-duration rice varieties. However, due to the impacts of climate on the fluctuation and extremities of flood and drought, the Thai Government has policies on reducing paddy area and introducing other economic crops more suitable to the soil and consume less water (RID, 2015). In ***Viet Nam***, the Mekong Delta is a major rice cultivation area. Around 60 percent of the rice grown in the Viet Nam Delta is irrigated and yields are considerably higher than in the other countries. In recent years, the Viet Nam Mekong Delta has annually produced around 20 million tons of rice mainly oriented for export (SIWRP, 2014).

In uplands or highlands of all the Member Countries, farmers in the past, especially ethnic minorities, practiced shifting cultivation. However, the agricultural practice has recently changed to increase annual and perennial economic/industrial crops, such as upland rice, maize, potato, cassava, sugarcane, Para-rubber, coffee, tea, cashew, and mulberry, etc. (IWRP, 2015; DOI, 2017). The expansion in terms of agricultural areas of the LMB will remain constant or decrease due to conservation and sustainability policies in all the countries, even though much of the land in the central highlands of Viet Nam, many of the provinces in Lao PDR

and parts of Thailand and Cambodia are mountainous and remain uncleared. The National Governments tend to promote new technologies that can increase agricultural yields; for example, seedling technology, resistant crop varieties, or modern practices. Agriculture will continue to be a major export earner and supplier of domestic food needs across the region. However, its contribution to the basin's economy will continuously decline due to the growth of commercial and industrial agricultural enterprises (MRC, 2010; MRC, 2017).

2.3 Irrigation sector

Irrigation has played a significant role in increasing agricultural yields and production to serve food security and export policies in the Member Countries of the LMB. It is also expected to decrease crop damage from water shortages in the dry season and expansion of cropping areas or flooding in the wet season for adaptation to the impacts of climate change. While the proportion of arable land that is irrigated is quite small, its productivity is much higher than from rain-fed cultivated areas. In Cambodia and Lao PDR, for example, rice yields in irrigated paddy in dry season and wet seasons are higher than those in rain-fed paddy by 35-65 percent and 20 percent, respectively (MRC, 2017). In many countries, water constraint shows a limitation in the development of agricultural production in dry season. Therefore, all Member Countries have policy and plans for irrigation development to enhance and protect crop production.

In ***Cambodia***, the irrigated area supports to agriculture are still limited, the major water resources for cropping systems are mainly from natural resources such as the Mekong river, Tonle Sap lake and river, and its tributaries. The irrigation development and rehabilitation has been constructed and operated by MoWRAM throughout the country in the last five years. The total area of 387,907 hectares of agricultural areas will continue to benefit from development based on the Strategic Development Plan (2014–2018) on water resources and meteorology. To maintain the irrigation system, the Royal Government of Cambodia has agreed on the proposed MoWRAM plan to introduce Water User Community's regulations to farmers throughout the country. This plan will increase the effectiveness of water usage and management and irrigation scheme maintenance by collecting irrigation service fees from beneficiaries to reduce expenses in maintaining irrigation schemes. During 2009–2013, MoWRAM established 109 farmer water-use communities (FWUC), where irrigation development benefits 13,899 households to expand 31,948 ha and 17,587 ha of paddy fields in rainy and dry seasons, respectively (Samphear, 2016).

In ***Lao PDR***, irrigation development started a few hundred years ago in the northern part of the country. There were many traditional irrigation schemes, in which the water level was raised by small dams made of logs, earth and stones, thus enabling the irrigation of about 30 ha during the wet season. In 1960, with foreign assistance, improvements were accelerated. Small concrete weirs and water distribution systems were built in several provinces. Before 1975, most rice farmers cultivated one floating rice crop without irrigation. In the following years, the rapid agricultural development was based on the development of short-term irrigated rice to increase rice production. Major irrigation development began in 1987. The Department of Irrigation (DoI) now provides central planning and coordination of irrigation development throughout the country. It also offers advice to provincial administrations on matters concerning irrigation services. The irrigation schemes are classified into 3 scales; small-scale schemes ranging from 1 to 100 ha; medium scale schemes from 100 to 500 ha; and large-scale schemes above 500 ha. Water control and irrigation systems developed in

the Mekong Basin of Laos for agricultural production consist mainly of the following types: dams, weir reservoir pumps and canal systems convey water for irrigation and conduct water into fields, draining excess rainfall; and the development of pump stations and small pump machines for irrigation and drainage; development of small dike systems for flood control to protect the safety of production; and sluice systems or temporary dams for salinity and flood control in the project area. Irrigation development is very important in increasing agricultural production due to climate change during the wet season year by year. Under the Lao Government Strategy for the agricultural sector, expanding irrigation development is major area of focus. In the Social Economic Development plan (SEDP) during 2011–2015, one of the specific targets is to increase areas under irrigated paddy by 400,000 ha in the wet season and by 300,000 ha in the dry season (DoI, 2017).

In ***Thailand***, gravity irrigation with open channel headworks is the typical irrigation system in many parts of the LMB, especially in the northeast of Thailand. The water from a large-scale dam, reservoir, or barrage type structure, such as large-scale weir with control gates, is usually transferred to agricultural areas throughout these gravity canal systems. Due to the very small gradient of the natural river bed, the barrages can effectively store large amounts of water forming a long lake along the river course. The sophisticated piped irrigation systems with small scale pump schemes are found along reservoirs or long lakes to reallocate water to the uplands. The combination of farm ponds with mobile pumps is widely used by smallholders in northeastern Thailand (MRC, 2014).

In ***Viet Nam***, irrigation systems in the Central Highlands are typical reservoir-gravity canal systems with active development of both surface and subsurface water resources. Around 20 percent of the irrigated area is used for rice cultivation and the remainder used for annual and perennial crops, such as cotton, soybean, cashew, coffee, and tea. Groundwater irrigation plays an important role in this area. Irrigation using private wells and pumps to take water from the plateau's unconfined aquifer to irrigate areas of rice and coffee plantation is normally used by smallholders in this area (MRC, 2014). In the ***Viet Nam Mekong Delta***, irrigation canal systems have been developed for over a century with the initial objective to develop water transportation. Since 1975, the irrigation systems have been rapidly developed for the purpose of increasing rice production. During 1975–1985, the irrigation pump stations with large and medium scale of 1,000 – 3,000 ha, and the largest up to 8,000 ha, were constructed. However, the irrigation area only reached 10–15 percent of the design capacity. Since 1985, the irrigation systems have been constructed more appropriately to create dense networks of irrigation channels that can provide the water source for operation of small pumping machines, irrigating around 10 to 100 ha, that can increase rice production. Recently, irrigation with small pumps is not very effective both in rice and orchard cultivation areas. In flooded areas of the VMD (1.9 million ha), a small dike system of about 1,000–2,000 ha controls flooding in the agricultural lands. Few sluices under dikes were constructed due to the limited capital investment. The earth dams were constructed instead for flood control; however, the dams are always broken and need maintenance every year. In the approximately 2 million ha of coastal areas affected by salinity, the embankment dams and culverts to control saline water intrusion to protect agriculture production have been developed (Thanh, N. D. and SIWRP, 2015).

Figure 1: Floating pump in Lao PDR

Figure 2: Irrigation canal in Thailand

Figure 3: Small electric pump in VMD

Figure 4: Sluice for saltwater control in VMD

Source: MRC, 2014 and Thanh, N. D. and SIWRP, 2015

3. Structure of the MRC Irrigation Database

3.1 Irrigation database framework

MRC's Irrigation Database needs to be updated and produced to be more user-friendly. The previous database – a complete set of AIFP 2004 irrigation database – is used as the basis of the GIS datasets for updating irrigation areas, irrigation reservoirs, and irrigation canals. In addition, the BDP 2009 irrigation data is mainly used for the update of irrigation projects and irrigation headworks. For cost effectiveness, Google Earth images will be used for verification of the 2004 data and digitizing new geographical features, such as polygons and canal lines. The major tasks in updating the new irrigation database are the following:

- Incorporate additional data from national databases;
- Incorporate informal irrigation/agricultural water management systems;
- Assess seasonal water-use in sample systems;
- Improve user-friendliness and documentation of the irrigation database;
- Incorporate additional data into the database, based on questionnaire surveys, for example: water supply (annual, seasonal) and inflow rates; estimated net water-use; estimated return flows; cropped areas and production; agricultural performance; system status; total operational costs; total production value.

The 2017 MRC irrigation database comprises of the five geo-spatial datasets, which are 1) irrigation projects, 2) irrigation headworks, 3) irrigation areas, 4) irrigation reservoirs, and 5) irrigation canals, and additional tabular data (in GIS format). The data was collected at different times in the Member Countries during the period 2013 – 2015. The information of data collection and updating are shown in the "Metadata". Among the five datasets, four except "Irrigation Canals" are anticipated to be maintained and shared every five years as a mandatory package in accordance with the MRC PDIES procedure. On November 1, 2001, the Council approved the Procedures for Data and Information Exchange and Sharing (PDIES) that established the MRC-Information System (MRC-IS) to receive, enter into datasets, store, maintain and make accessible data and information for the MRC. The MRC-IS is a structured communication and management system for data and information. Its ultimate goal is to support the activities (planning, development, decision making, and monitoring) in the framework of the Mekong Agreement. For more information, please search through the "MRC Procedures" webpage in MRC web portal at this following link – ***http://portal.mrcmekong.org/mrc-procedures***

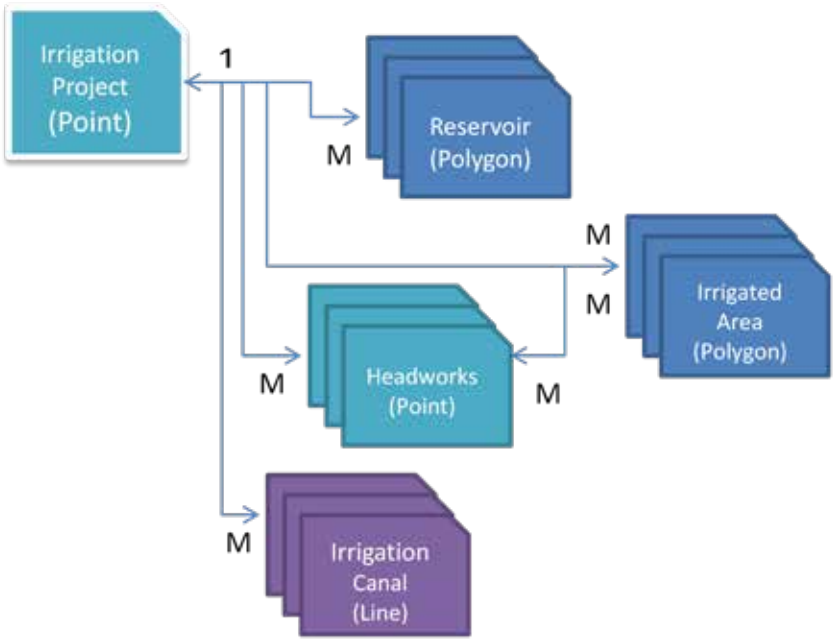


Figure 5: Conceptual relationships among the new irrigation datasets

3.2 Structure of spatial data

Each dataset of the new irrigation database is in GIS format, attached with attribute tables, and is linked through a single code given for each irrigation scheme. The "Irrigated Area" datasets and "Irrigation Headworks" are also linked by an additional code given to each headwork. The geographical projection used for the database is the Universal Transverse Mercator system with the World Geodetic System 1984 or UTM WGS 1984 in meter unit. The five spatial datasets are explained as the following:

Irrigation Projects: A point type layer of irrigation projects including existing and planned projects. The previous Irrigation Project 2009 data with coordinates X and Y were used as the basis for verification and update. Information to be recorded in this dataset is project name, code for representative location, XY coordinates in UTM systems, country code, name of agency, operational status, year of completion, project function, crop code, soil legend, project cost, number of storage dams, number of diversion works, length of main and secondary canals, number of pumping stations, number of irrigated farms, farmers' role in OM&M, typical field application method, and irrigable areas.

Irrigation Headworks: A point type layer of irrigation headworks that contains XY coordinates of the headwork location in UTM systems, headworks type, name of intake river, and the maximum intake volume.

Irrigated Areas: A polygon type layer of irrigated area under each headwork that contains the headwork ID and existing irrigated area in the wet season which is automatically generated by the GIS function.

Irrigation Reservoirs: A polygon type layer of irrigation reservoir that contains the name of the dam or reservoir, type of structure, purpose, active total capacity, and active capacity for irrigation.

Irrigation Canals: A line type layer of irrigation canal that contains canal length, its classification, structural type, and canal condition. (Non-mandatory dataset)

3.3 Structure of attribute dataset

Every spatial database is always attached with an attribute table for describing information of each feature in detail. Five datasets of the MRC Irrigation Database also have attribute tables attached with them. The data fields and structure for attribute datasets of each spatial dataset are described in detail in ***Annex 1***.

4. Methodology

4.1 Irrigation database improvement

4.1.1 General approach

MRCS firstly developed the project proposal and set up a framework, action plan and created a data structure of the new MRC irrigation database to share with the Member Countries through regional/national consultation meetings. After it was improved and revised based on MCs' comments, the final data structure was distributed to the proposed national working groups. After that, the national working groups reviewed the available irrigation database, including the existing MRC irrigation databases of 2004 and 2009, national and local irrigation databases both in GIS format, excel file and hard copy. Auxiliary data and information supported irrigation database improvement, for example, topographic maps, land use maps, river basin and contour line maps, aerial photographs and satellite imagery, statistic documents, and other hard copy data and documents. The national working groups then gathered all data and information, analyzed and prepared for transfer of data into GIS format as required by MRC data structure by various methods such as scanning, extracting, geo-referencing, digitizing, and validating with auxiliary data. The Quality Assurance and Quality Control (QA/QC) process and metadata formation were conducted at national level prior to submission to MRCS. After receiving the results from each MC, MRCS again conducted 1st and 2nd QA/QC process and provided technical reports for the MCs for further improvement. The national working groups/national consultant provided an improved and revised national irrigation database based on MRCS comments. Towards the end, MRCS consolidated national datasets and developed the regional irrigation database with final QA/QC and technical errors correction, generated the regional metadata, and consolidated and synthesized the country reports, finalizing as the 2017 (considering the most recent year of update) regional report of MRC irrigation database improvement.

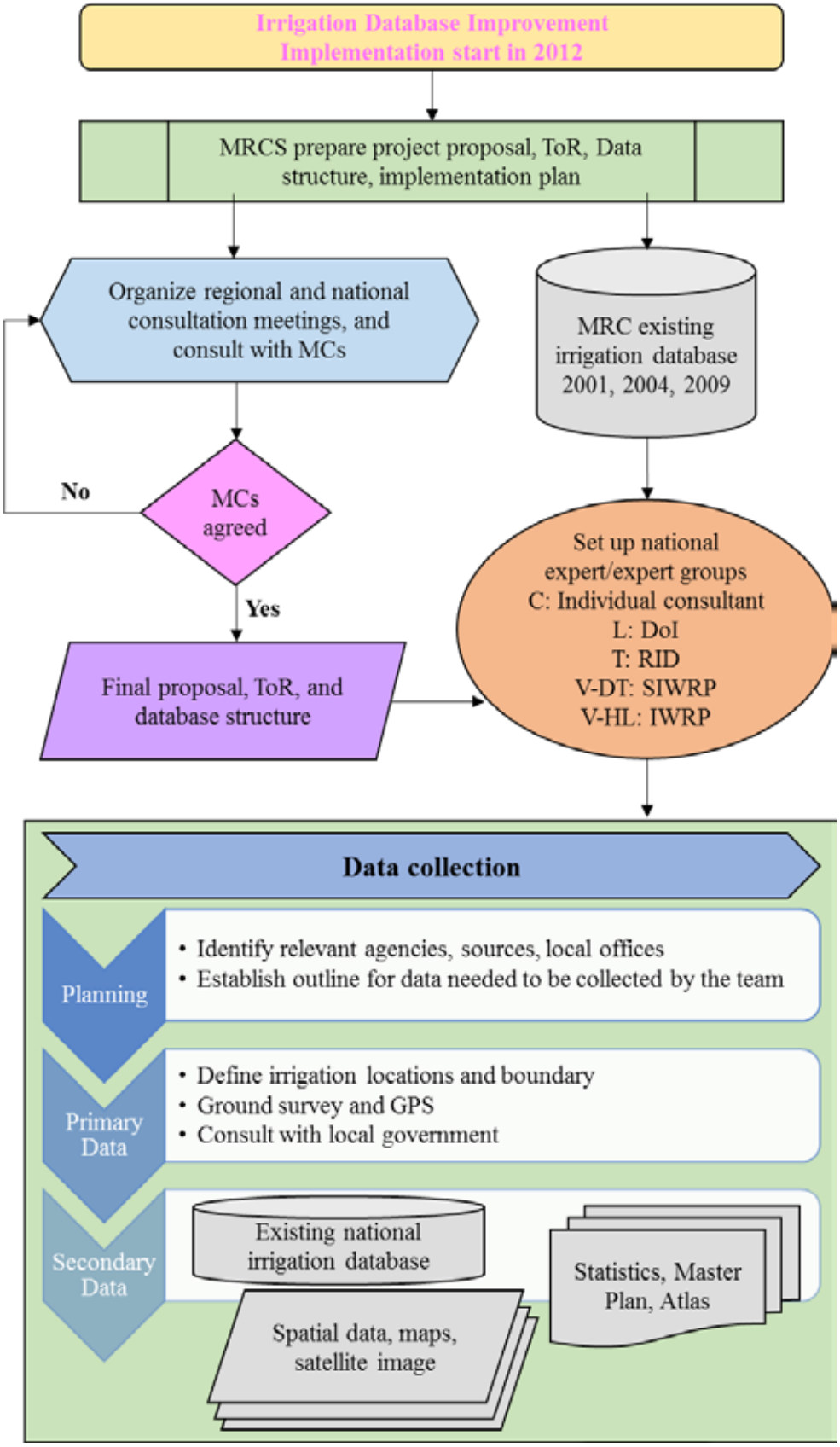


Figure 6: Approach for improvement of the irrigation database

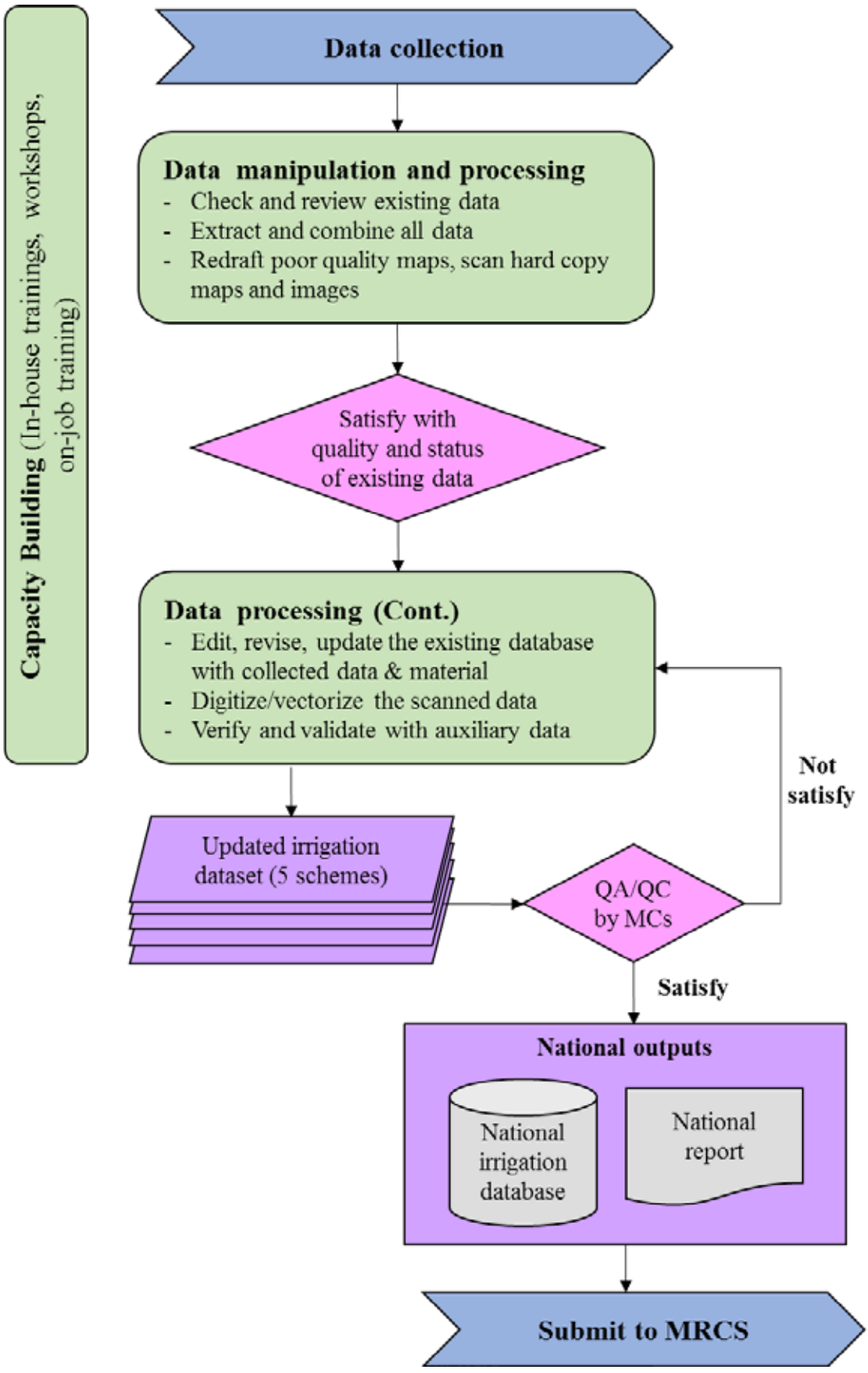


Figure 6: Approach for improvement of the irrigation database (Continued)

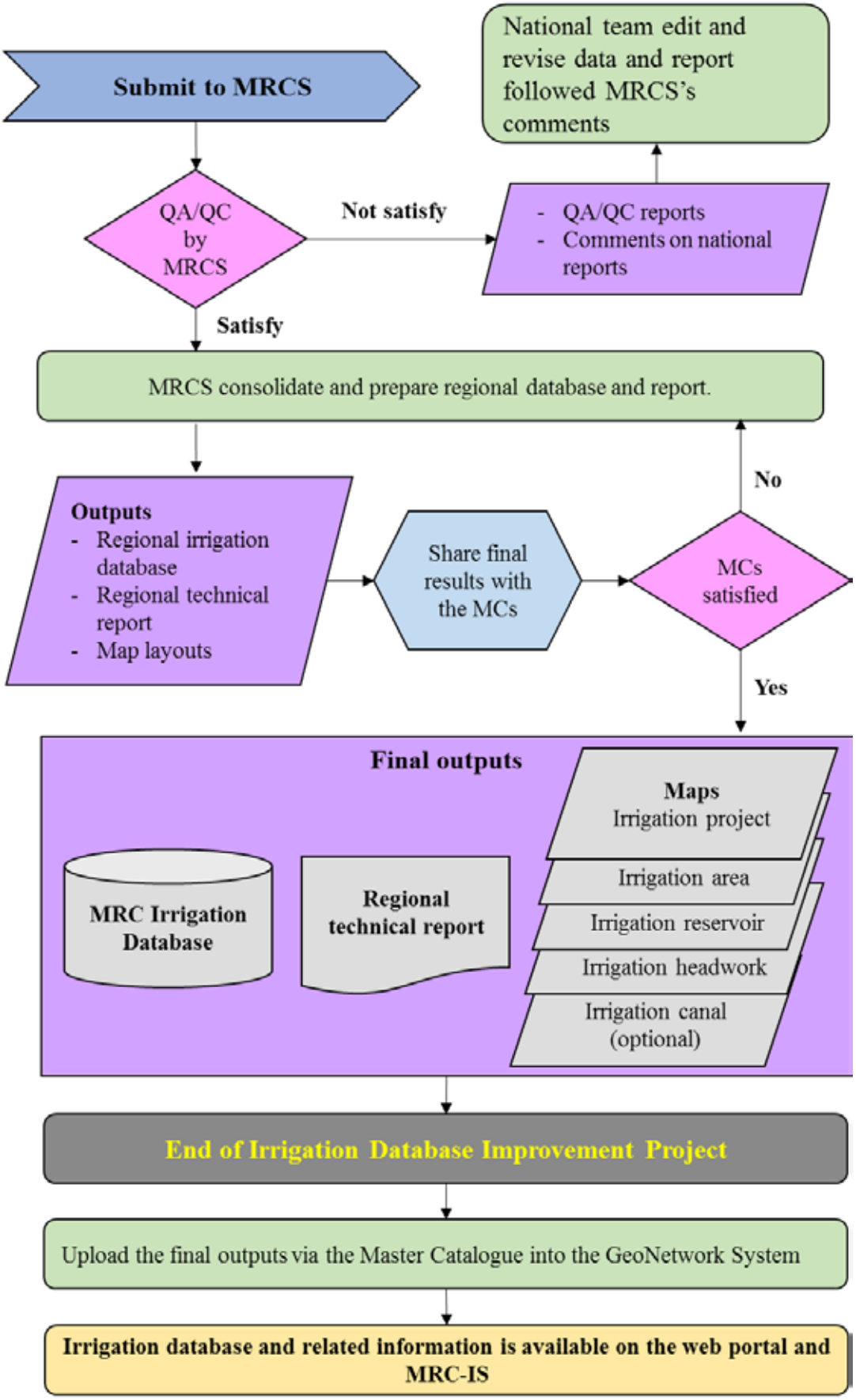


Figure 6: Approach for improvement of the irrigation database (Continued)

4.1.2 Data collection

The national working groups/national consultant collected relevant secondary data within their own organizations for the irrigation database improvement, and from different line agencies, local and national offices and institutions, and/or online data sources. The field data collection was conducted in all countries except Cambodia due to different channels of participation in the improvement project. The purposes of field work are different among the four working groups based on their available data and information; for example, to supplement the missing documents and data; to define the actual boundary of the irrigation areas; and to determine the correct location. The details of data collection of each national work team are summarized in ***Table 2***.

4.1.3 Data analysis and processing

The national working groups/consultant reviewed all collected available irrigation databases, comparing them to the irrigation database structure required by MRCS. The irrigation data in all countries are diverse but lack good arrangement, are inconsistent, not in detail, not standardized, and some data are not stored in GIS or even digital format. Some information is not available or not up-to-date; therefore, primary data collection took place in some countries to ensure accuracy or to create and rebuild the existing datasets. Similar techniques for data analysis and processing were conducted using GIS environment; for example, digitizing, redrafting, editing, and revising the current datasets and verifying updated auxiliary data such as topographic maps, aerial photographs, satellite images, and field data collection. The details of data analysis and data processing of each national work team are summarized in ***Table 3***.

Table 2: Summary of data collection for irrigation database improvement in the MCs

Data collection	Activity				
	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Planning	The national consultant planned for data collection through various consultation with different units and sources, including Cambodia Mekong committee, MRCS-AIP Council Study team, Ministry of Water Resources and Meteorology, Website, and national Council Study team, in order to gather all available irrigation databases and relevant information.	• Establish an outline that specifies the contents of the database needed to be collected for the national working group to increase the efficiency of the mission at the local level. • Identify the agencies needed to be met with, including the Department of Irrigation, provincial irrigation sectors, and district irrigation unit offices.	• Set up national working group and organize meetings to set up framework and implementation plans and discuss the revised template of new irrigation database to the national working group.	• Establish an outline that specifies the contents of the database needed to be collected for the national working group to increase the efficiency of the mission at the local level. • Identify the agencies needed to be met with, including the Department of Agriculture and Rural Development and its specialized offices, Department of Natural Resources and Environment, the Division of Agriculture and specialized divisions directly under the District People's Committee.	• Establish user requirements, gathering resources, and developing a project plan

Data collection	Activity				
	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Primary data collection (field work)	N/A	• Carry out many field trips to work with the provinces, to supplement the missing documents during July-September 2014. National working groups were divided into 4 groups for data collection for each province of Laos: • Group 1: went to the North West part of Sayabuly, Luangphabang, Vientaine and Xiengkhuang Provinces during period 05- 18 July, 2014. Group 2: went to the Middle part of Vientaine Capital, Borikhamsay, Khammouane and Savannakhet Provinces during period 25 July - 07 Aug, 2014. Group 3: went to the Southern part of Champasak, Saravan, Xekong and Attapue Provinces during period 15-28 Aug, 2014. Group 4: went to the North East part of Phongsaly, Oudomsay, Luangnamtha and Bokeo Provinces during period 05- 20 Sep,2014.	• Field work was conducted to define actual irrigation area and canal boundaries.	• Carry out many field trips to work with the provinces, to supplement the missing documents during July-August 2013. National working groups were divided into 2 groups for data collection: Group 1: went to the provinces of An Giang, Kien Giang, Ca Mau, Bac Lieu, Hau Giang, Can Tho and Vinh Long. Group 2: went to the provinces of Dong Thap, Tra Vinh, Ben Tre, Tien Giang, Long An and Soc Trang.	• Employ ground surveying and GPS based on the principle that the 3-D location of any point can be determined by measuring angles and distances from other known points. Traditional equipment like transits and theodolites have been replaced by total stations that can measure both angles and distances to an accuracy of 1 mm.

Data collection	Activity				
	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Secondary data collection	• Conduct data collection within national key line agencies, including National Mekong Country programs such as AIP, IKMP, BDP and Ministry of Water Resource and Meteorology (MoRAM) both spatial and non-spatial data, and statistical information. • Extract data and information from external sources sharing and available on web browser • Collect data from national council study consultant on irrigation specification.	• Gather the available data, which DoI has accumulated over decades, including digital data and other previous databases (paper documents, maps). • Collect the latest statistics of the provinces, and other relevant data at the local level for comparison with field surveys. • Work with provincial irrigation sector and district unit office of DoI to collect the missing data and information.	• Gather available GIS data, including topography maps, google maps, land-use maps, road maps, rivers, basin and sub-basin, contour line, water bodies, and administrative boundaries. • Gather data construction drawing in hard copy or digital as available, including irrigation project maps, irrigation structure/headworks (location and boundary), irrigation project areas, irrigation canals, irrigation area boundaries. • Collect other support data in Excel and from field inspection, ortho map (30 m.). • The collection of existing irrigation data was collected at regional level by Regional Irrigation Office.	• Gather the available data which SIWRP has accumulated over decades, including digital data and other previous databases (paper documents, maps). • Collect the latest statistics of the provinces, and other relevant data at the local level for comparison with field surveys. • Collect documents from the scientific research units, such as Sub-National Institute of Agricultural Planning and Projection, the Southern Institute of Water Resources Research, Hanoi Water Resources University, Board of Investment Management No.10, and Hydraulic Engineering Consultants Corporation No.2.	• Collect and/or scan, and geo-reference digital and analog datasets that were originally captured for other purposes, including film and paper maps, aerial photographs, and images.

Table 3: Summary of data analysis and data processing

Data analysis and data processing	Activity				
	Cambodia	**Lao PDR**	**Thailand**	**Viet Nam-Delta**	**Viet Nam-Highlands**
Preparation for data transfer (Data analysis)	• Check and review database quality and status of the existing data, including BDP database in 2009, MRCs irrigation database in 2001, AFIP irrigation data in 2004, and irrigation project in Council Study.	• Analyze the status of collected data and information and extract data gaps of the existing data compared to the data format and structure required by MRCS.	• Extract and combine all collected spatial data, verify and reformat into MRCS required format. • Set up 5 new layers, including irrigation projects, headworks, areas, reservoirs, and canals.	• Analyze the status of collected data and information and extract data gaps of the existing data compared to the data format and structure required by MRCS.	• Redraft poor-quality map sources • Edit scanned maps and images • Remove noise • Set up appropriate GIS hardware and software systems to accept data.
Data transfer, processing, and managing	• Use ArcGIS software for data processing, digitizing, updating, checking, validating, and mapping support with report bidding. The Google Earth and recently available satellite images are also used to support data comparing, digitizing, and checking as well.	• Edit, revise, and upgrade the collected data and materials to satisfy the requirements of MRCS.	• Verify irrigation headworks and canals with topography maps and google maps. • Verify irrigation areas and projects with topography and google maps, aerial photographs, land use maps and road maps. • Use water body shapefile to set up irrigation reservoirs and verify with topography and google maps, location of headworks, and contour lines. • Digitize additional data and eliminate non-relevant data.	• Edit, revise, and upgrade the collected data and materials to achieve the requirements of MRCS.	• Digitize/vectorize the scanned data into a suitable digital format used in GIS project. • Capture attribute by direct data loggers, manual keyboard entry, optical character recognition (OCR) or, increasingly, voice recognition. • Edit, validate, and correct errors of data to improve data quality. • Evaluate project successes and failures.

4.1.4 Database improvement process at national level

- Since the beginning of 2012, the Agriculture and Irrigation Programme (AIP) proposed the study documents and new structure of the MRC irrigation database to the MCs and conducted consultation workshops to collect the MCs' comments for revision of the study documents and to agree on the data structure of the regional irrigation database.
- The MCs set up national working groups, identified and assigned responsibilities to members of the working groups, then developed the workplan and work schedule.
- Review, analyze, and review the existing MRC irrigation database comprised of shapefiles and Excel sheets, and existing national data.
- Review and discuss with MRCS on the data structure of the new irrigation database and other requirements.
- Capacity building of GIS training provided through training, workshops, and on-the-job training.
- Collect additional essential GIS-based irrigation data, existing documents, and auxiliary data from relevant agencies.
- Carry out field survey and field data collection as necessary to define actual locations and improve accuracy of the data.
- Add new records to the given datasets when additional irrigation systems/structures are identified.
- Collect additional materials to digitize, edit, revise, and update the existing GIS-based irrigation data to achieve perfection as required by MRCS.
- Create detailed metadata.
- Validate the irrigation database by carrying out quality assurance and quality control (QA/QC) using topology/data reviewer application and verify the results with other sources of data, such as google maps, satellite images, aerial photographs, and make the necessary corrections.
- Prepare and submit the final national irrigation database and technical report in a timely manner and according to guidelines given by MRCS.
- Propose a plan to maintain, regularly update and share with MRCS, and utilize the new database and implement the plan establishing necessary national capacity.

4.1.5 Quality assurance and quality control (QA/QC)

The final irrigation database was applied QA/QC both at national and regional levels based on a checklist and procedure appointed by MRCS. The ArcGIS data review tool was used to clean all existing datasets after applying spatial data processing. More details on the QA/QC are provided in Chapter 7.

4.2 Capacity building

To maintain and utilize the database, the Member Countries conducted capacity building in various forms.

Training courses: national technicians involved in the project received capacity building through several training courses on GIS techniques and application and QA/QC process to enhance their capacity in establishing and processing geo-spatial database, checking data quality, and maintaining the database.

Office and document support: The manual and guidelines, support data and information, maps, tools and equipment, technologies, and available databases for establishing the irrigation database was provided to national working groups to broaden their knowledge and understanding to prepare for project implementation.

On-the-job training: The experienced technicians, who had more expertise in irrigation database improvement in the working group, trained and provided instruction and coaching for the junior technicians in the group during the period of project implementation.

Project implementation: During the period of project implementation, members of the working group experienced some problems and solutions, and improved their knowledge and skills on GIS and spatial database improvement.

4.3 Reporting

4.3.1 Internal report within the working group

Members of the national working groups regularly exchanged and discussed during different phases of project implementation, such as at the beginning of the project, time execution of the project, and the finalization stage in the meetings, via email communication, and during the participation and consultation of the team with external experts and local offices.

4.3.2 Report to MRCS

The progress and quarterly reports were submitted to AIP and NMCs as prescribed on the contents to cover the activities and tasks completed in the most recent reporting period, shown by timetable; the proposed action plan and the necessary tasks for the coming period; and outlined the difficulties while implementing the irrigation data program.

5. Implementation Process of the Irrigation Database Improvement

5.1 Results from checking existing irrigation databases

5.1.1 Short description of the existing irrigation databases

There are three historical irrigation databases available at the MRC Secretariat; the irrigation database 2001, 2004 and 2009 that were collected for different purposes. The irrigation database 2001 was developed as the complete irrigation spatial dataset, which included full geographical coverage of most irrigation schemes of the LMB. It includes the information on existing irrigation schemes as five spatial GIS files (project, headworks, areas, reservoirs, and canals) supported by excel data files for each country. Each irrigation dataset is linked by a unique code assigned for each project. This basin-wide irrigation database was developed under the Japanese support to the LRIAD project and the data was compiled by the national line agencies in four Member Countries. In 2005, the irrigation database 2004 was updated from the earlier 2001 dataset to present basin-wide water-use in the irrigation sector. This project was under Japanese support to the Demonstration of Multi-functionality of Paddy Fields (DMPF) Project implemented under the former Agriculture, Irrigation and Forestry Programme (AIFP). Before the current irrigation database improvement project initiated in 2012, the most recent update of the irrigation database was the BDP 2009 database which, was the update of the earlier 2004 irrigation database. The main purpose for the update was to carry out an irrigation requirement scenario in 20 years' time. The database was mainly in Excel and Access formats and, hence, the geographical features of irrigation systems were not included.

For this project, the term **"old irrigation databases"** means the existing AIFP irrigation database 2004 and BDP irrigation database 2009. The most recent update of the irrigation database, which is BDP 2009 database, contains full spatial irrigation features used as the base GIS datasets for the irrigation database update, particularly for Irrigation Areas, Irrigation Reservoirs, and Irrigation Canals. The data provided to each Member Country includes four basic layers and 1 access file as follows:

1) IAREA_04C4.shp Irrigation Areas
1) IHW_04C4.shp Irrigation Headworks
1) IPROJ_09C4.shp Irrigation Reservoirs
1) IRESV_04C4.shp Irrigation Projects
1) Irrigation2009.mdb BDP Database for LMB

5.1.2 Checking the databases

The Member Countries received the MRC irrigation databases of 2004 and 2009, which are also available on the MRCS Web portal for downloading. For cost effectiveness, the National Working Groups also used auxiliary data such as Google Earth images, existing country digital maps, and secondary irrigation datasets, etc. from various reliable sources for checking and verifying the existing MRC database, filling the data gaps, data processing, and additional digitizing of features. The national experts checked the MRC irrigation databases of 2004 and 2009 before updating the data for each required irrigation scheme, including irrigation projects, headworks, areas, reservoirs, and canals. The results of checking the existing irrigation database in each Member Country can be summarized in ***Table 4***.

Table 4: Summary from the check of the old irrigation databases in each Member Country

Scheme	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Irrigation projects	There are 1,100 irrigation schemes measured on sites or made by Google earth analysis and ground truthing.	There are 5,100 irrigation projects, represented by points, in IPROJ_2004 and BDP_2009 files that are classified in the Mekong Basin of Lao by DoI.	There are 7,363 irrigation projects in the 2004 and 2009 MRC database including large, medium, and small projects. However, the small-scale irrigation projects in the old database are only of potential benefit with no irrigation systems applied due to insufficient budget.	There are120 irrigation projects, represented by points, in IPROJ_09C4 shapefile, which are classified in Mekong Delta by SIWRP since 1996.	There are 826 irrigation projects recorded in BDP 2009 database, including 563 reservoirs, 119 dams, 46 weirs, 9 hydropower dams, 9 lakes, 60 pumping stations, and 20 others.
Irrigation headworks	There are 324 records of irrigation headworks in the 2004 database only, representing headwork points.	There are 5,100 irrigation headworks in IWHW_2004 shapefile. However, after checking with irrigation system maps of GND, some headworks in the 2004 database have not yet been constructed or do not exist, and they were removed. Only 3,162 headworks are used for data update to fix their location and fill the name gaps.	There are 8,764 records of irrigation headworks in the 2004 database only, representing as headwork points.	There are 1,149 irrigation headworks in IWHW_04C4 shapefile. However, after checking with the irrigation system map of SIWRP, there are some headworks that have not yet been constructed. Therefore, only 159 of the major headworks are kept for fixing their locations.	There are 100 records of irrigation headworks in the existing 2004 irrigation database.

Scheme	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Irrigation areas	There are 239 polygons with cover irrigation area of 520,339 ha.	There are 707 polygons with cover irrigation area of 175,851 ha. After checking, the boundary of polygons is consistent with DoI's materials. Only some areas need information and location for better accuracy.	There are 2,488 polygons with cover irrigation area of 2,473,568 ha in the old irrigation database, which is double the actual irrigation areas with the potential benefit areas and so an overestimate.	There are 120 polygons with cover irrigation area of 3,953,893 ha.	There are 76 polygons with cover irrigation area of 65,280 ha.
Irrigation reservoirs	There are 240 records of irrigation reservoirs in the existing 2004 irrigation database.	There are 130 irrigation reservoirs represented in IRESV_2004 shapefile. After checking, the boundary of polygons is consistent with DoI's materials. Only some areas need information and location for better accuracy.	There are 578 records of irrigation reservoirs in the existing 2004 irrigation database.	There is no irrigation reservoir feature in Mekong Delta in the old irrigation database.	There are 46 records of irrigation reservoirs in the existing 2004 irrigation database.
Irrigation canals	There is no irrigation canal feature in either old database.				

5.1.3 Linkages between spatial data and attribute data and amongst attribute tables

There is a linkage of each layer of the old irrigation databases in 2004 and 2009 using project ID and BDP ID. It is found that the project ID were defined in an inconsistent manner. For example, some codes are all numeric, some are mixed with letters. The project ID is the same code as BDP ID for both 2004 and 2009. The conceptual design of relational database aimed at creating linkages between tables of geospatial and non-geospatial data within each of six databases including the irrigation database. The Irrigation Project dataset was used as the primary data to be linked with other dataset's tables of the irrigation database. The MRC_ID unique code field was then developed, and unique values were assigned to all projects of the Irrigation Project dataset. A relational database is a collection of datasets/tables which can be related to each other through a common field. The common field of the primary table contains primary keys which are all unique values; while the common field of the other tables contains foreign keys, which are either unique or duplicate. Each foreign key is identical to one of the primary keys to which it is related.

According to the report on the Relational Database Design, the relationship between tables were established in three different types: (a) one-to-one [1:1]; (b) one-to-many [1:m]; and (c) many-to-many [m:m].

- *A one-to-one [1:1]* relationship occurs where each record of Table-A matches only one record of Table-B and vice-versa.
- *A one-to-many [1:m]* relationship occurs where one record of Table-A matches two or more records in Table-B while one record of Table-B could match only one record of Table-A. This type of relationship is by far the most common type.
- *A many-to-many [m:m]* relationship occurs where each record of Table-A matches many records of Table-B, and each record of Table-B matches many records of Table-A.

Figure 7 shows the conceptual model of the irrigation database designed from the original irrigation datasets 2004/2009. According to the report on the conceptual design, the original irrigation datasets were set up as individual datasets with no relationship built with other tables. It indicates that the relationship between Irrigation Projects and Irrigation Canals is one-to-many, [1:m], relationship through MRC_ID because each project of the Irrigation Project contains more than one irrigation canal of the Irrigation Canal. Similarly, the Irrigation Project has one-to-many relationship with the Irrigation Headworks through MRC_ID because one project of the Irrigation Project data could contain more than one headwork while one headwork belongs to only one project. On the contrary, the relationship between the Irrigation Project and the Irrigation Data (Additional Data) is one-to-one relationship through MRC_ID because there is only one record of information of the Irrigation Data, e.g. Area Wet (irrigation area in wet season), belonging to one project of the Irrigation Project. Lastly, the relationship between the Irrigation Project and Irrigation Canal through Ccode field is a many-to-many relationship because one project of a country, e.g. Cambodia has Ccode 1, of the Irrigation Project could match many canals of Cambodia with Ccode 1 of the Irrigation Canal and vice versa.

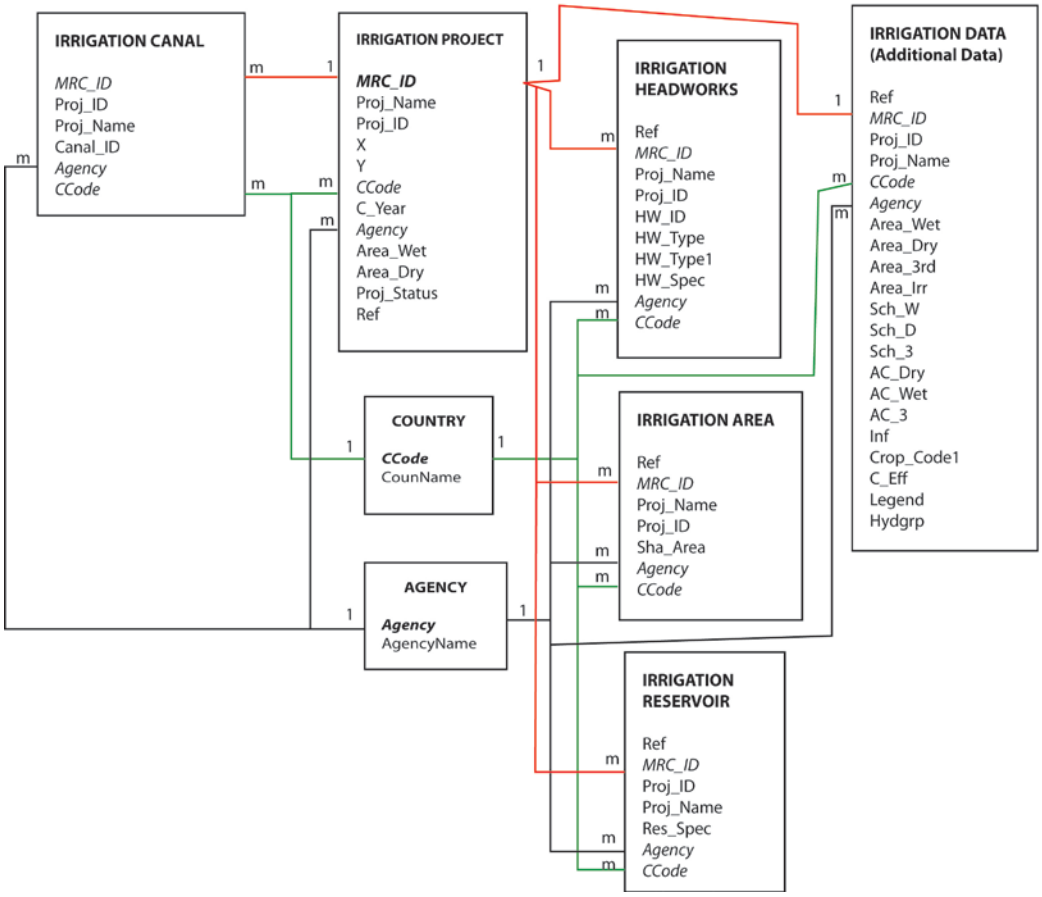


Figure 7: The conceptual model of relational irrigation database design

5.1.4 Advantages and disadvantages of the databases

Advantages of the existing databases are that they can be used as basic information for irrigation project name, code, and location. Data of irrigation projects and areas are quite suited with the available national database. However, in the old database there are many irrigation projects and areas that do not exist or the information is out of date. Some identified irrigation areas are not the real irrigated areas but only the potential areas for development of irrigation systems. In all four Member Countries, the points of irrigation headworks in the old database are mostly not real and placed in the wrong location. The irrigation canal is not available.

5.2 Collection of essential GIS-based irrigation data from relevant line institutions/agencies

Each national expert/working group collected data that are useful for MRC irrigation database generation from various departments, organizations, sources, and line agencies. The existing data are available in different forms and formats such as Shapefile, MapInfo file, raster data, excel file, hard copy, etc. Lists of data collected in each Member Country are shown in ***Table 5***.

Table 5: Summary of data collected from relevant sources in the Member Countries

Group	Type	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Spatial data						
Existing irrigation data	Geodatabase	MRC irrigation databases of 2004 and 2009 provided by NMCs or retrieved from Master Catalogue of MRCS Web Portal				
	Spatial file (Geo-datasets, Shapefile, MapInfo file), AutoCAD, hard copy	- MRCS irrigation database of 2001 from MRCS Master Catalogue - AIP irrigation field data collection of 2015 from Irrigation thematic area of MRC Council Study - Canals data from Open Development Center (www.opendevelopment.org)	n/a	Existing irrigation projects and layout maps, structure/ headwork, canals, boundary, and project areas from RID Regional Office	Existing irrigation system 2008 in the Mekong Delta included canal, road, administrator, sluice system maps of SIWRP	Existing irrigation system 2013 including canal, road, administrator, sluice system maps of IWRP
Satellite images	Google earth	*n/a*	Google Earth			

Group	Type	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Aerial photographs	Raster file	n/a	Aerial photos of 2011	Orthophotos 30 meters	n/a	n/a
Base map	Raster file, MapInfo file	n/a	Base map scale 1:100,000 of Lao PDR	Topographic map scale 1:50,000 from Royal Thai Survey Department	Base map scale 1:50,000 from MONRE	
Other baseline data	Shapefile, MapInfo file	- Ministry of Land Administrative boundary and river from Management, Urbanization and Construction (MLMUC) - LMB boundary from MRCS	Existing land-use map 2011 of Mekong Basin of Laos in 17 provinces	- Existing land-use map from Land Development Department - Commonly used/ shared GIS data including maps of road, river, basin and sub-basin, contour line, water bodies, and administrative boundaries	- Existing land-use map of 2008 of the Mekong Delta in 13 provinces from SUB-NIAPP - Soil maps of the Mekong Delta from IKMP, MRCS	- Existing land-use map of 2013 in 6 provinces from NIAPP - Soil maps of the study area from IKMP, MRCS

Group	Type	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Non-spatial data						
Statistics	Excel file, hard copy	n/a	Statistics of existing irrigation system 2013 of the Mekong Basin of Laos in 17 provinces for location of irrigation projects of DoI	Irrigation project data from existing data collection of RID regional office and additional field inspection	Statistics of 13 provinces in the Mekong Delta 2008-2012 from General Statistics Office	Statistics of 6 provinces 2008-2013 from General Statistics Office
Documents and reports	Documents, PDF files, hard copy	Irrigation project location (2015-2016)	*n/a*	*n/a*	- Master Plan of Mekong Delta in the term of Climate Change and Sea Level Rise (2011) of SIWRP - Vietnam Administrative Atlas	- Master Plan of Central Highlands in the term of Climate Change (2013) of IWRP - Vietnam Administrative Atlas

5.3 Added data in the database for new irrigation systems/structures

The new attribute data and newly featured shapes were created for all records when new irrigation structures were identified. Information described in various data sources and data analysis tools were used for each type of object and show the number of new projects, headworks, reservoirs, and canals. After checking the data of old irrigation databases, the national expert/working groups used the national available relevant data as present in section 5.2 to update and input the requirement attribute for datasets. Based on availability of existing data and up-to-date information in each country, the national expert/working groups have considered to keep, modify, or remove existing data and information to make the database more accurate. They have also updated and generated the new irrigation database with different conditions in each irrigation scheme to make the database more reliable with the most updated data and information in the countries. The data addition and modification for each irrigation scheme in the Member Countries are shown in Table 6.

5.4 Update of the old GIS-based irrigation data by undertaking ground surveys with questionnaires at country level and GIS-based work

The new irrigation database has been generated and updated from secondary data through collecting various types of data and information from local governments, institutions, and organizations, and primary data through field data collection in all Member Countries, except Cambodia. There is no removal of the spatial objects in Cambodia, Lao PDR, and Vietnam. However, as mentioned in the previous section, Thailand has recently and fully updated its irrigation database based on the national irrigation data and improvement during 2012–2013, so that some objects of irrigation schemes, which do not exist or have not yet been constructed, were removed in the newly submitted national database. The confirmation of updated data by undertaking ground surveys in the Member Countries is summarized in Table 7.

Table 6: Data addition and modification of irrigation schemes in the MCs

Schemes	Cambodia	Lao PDR	Viet Nam-Delta	Viet Nam-Highlands
Irrigation projects	• Spatial join and check the consistency and duplication of the old MRC databases • Keep 927 projects of matching locations from 2004 and 2009 data sources and remove the overlapping data • Update and revise 1198 points from existing databases • Combine 14 new irrigation projects in 2015 data collected by MoRAM and national team of MRC Council Study	• Keep the completed objects of the old irrigation databases including 3,161 projects • Remove all fields except BDP_ID • Add the proportion fields as required structure of the new irrigation database • Input the required data and information from the available data of DoI.	• Keep the completed objects of the old irrigation databases including 120 projects • Remove all fields except BDP_ID • Add the proportion fields as required structure of the new irrigation database • Input the required data and information from the available data of SIWRP	• Keep the completed objects of the old irrigation databases including 1,360 projects • Remove all fields except BDP_ID • Add the proportion fields as required structure of the new irrigation database • Input the required data and information from the available data of IWRP

Schemes	Cambodia	Lao PDR	Viet Nam-Delta	Viet Nam-Highlands
Irrigation headworks	• Keep the same record from the old database • Add missing attribute information from the irrigation area and reservoir schemes	• Create the new attribute structure as required structure of the new database • Add new features from the statistics of existing irrigation system 2014 in Mekong Basin of Lao and compare with Google Earth imagery and aerial photos to update 2,218 weirs, 69 diversion gate/regulator, 549 pumping stations, 257 reservoirs and 60 other types • Input other required data and information in the attribute table from existing materials and reports of DoI.	• Create the new attribute structure as required structure of the new database • Add new features from existing irrigation system 2008 in the Mekong Delta Map and compare with Google Earth imagery to update 691 weirs and 30 main pumping stations • Input other required data and information in the attribute table from existing materials and reports of IWRP, such as name of implementing agency, river intake, type of headworks, etc.	• Create the new attribute structure as required structure of the new database • Add new features from existing irrigation system 2013 in the study area and compare with Google Earth imagery to update 1,360 irrigation headworks, 670 dams and reservoirs, and 389 canals • Input other required data and information in the attribute table from existing materials and reports of IWRP such as name of implementing agency, river intake, type of headworks, etc.

Schemes	Cambodia	Lao PDR	Viet Nam-Delta	Viet Nam-Highlands
Irrigation areas	• Validate the existing irrigation area location with google earth and confirm 287 irrigation areas with completed information • Add irrigation area from the additional field data collection from irrigation thematic of Council Study and update 165 areas that lack information • Digitize new location comparing with irrigation canals, projects, and reservoirs	• Keep the completed objects of the old irrigation databases including 250 polygons. • Adjust the boundary of irrigated areas to suit the transportation and canal systems • Create new attribute structure as required • Add data and information from ground surveys and participatory mapping for additional fields; for example, actual irrigable area, cropping condition, number of pumping stations, and project function, etc.	• Keep the completed objects of the old irrigation databases including 120 polygons • Adjust the boundary of irrigated areas to suit the transportation and canal systems • Create new attribute structure as required • Add data and information from ground surveys and participatory mapping for additional fields; for example, actual irrigable area, cropping condition, length of main canal, type of field application, etc.	• Keep the completed objects of the old irrigation databases including 1,360 polygons • Adjust the boundary of irrigated areas to suit the transportation and canal systems • Create new attribute structure as required • Add data and information from ground surveys and participatory mapping for additional fields; for example, actual irrigable area, cropping condition, number of structures existing in the project, project functions, etc.

Schemes	Cambodia	Lao PDR	Viet Nam-Delta	Viet Nam-Highlands
Irrigation reservoirs	• Add 69 irrigation reservoirs from data collection of Council Study and digitizing based on google earth and other reference sources • Combine and remove the duplicated locations of other 39 reservoirs from 2001 and 2009 MRC irrigation databases and MoRAM data	• Adjust location for more accuracy and combine with the new available data. The total number of 257 reservoirs (previously 130 reservoirs) for irrigation supply purpose are included in the new irrigation database of the Mekong Basin of Laos	• No additional data collection.	• Collected data and information of 670 dams from several data sources and input in the new irrigation database
Irrigation canals	• Combine irrigation canals from different data sources such as MRC irrigation databases of 2001, 2004, 2009, and Council Study, and ODC data • Digitize and correct the old data location by checking and overlaying with Google Earth and irrigation areas and reservoirs • Fill up the required attribute data with information of irrigation areas using spatial join tools	• No data collections	• Create new features from the existing canal maps of SIWRP. The total number of 5,652 canals with 36,578 kilometers are included • Input the required data from SIWRP reports • Generate the length of canals automatically by ArcGIS software	• Create new features from the existing canal maps of IWRP. The total number of 389 canals with 361.12 kilometers are included • Input the required data from IWRP reports • Generate the length of canals automatically by ArcGIS software

For Thailand, since the existing MRC database combined many small-scale irrigation projects, which have not yet been constructed and with location errors, RID has newly and fully updated and conducted the new irrigation database of Thailand from the "Irrigation Area Investigation Project in Thailand", carried out during 2012–2013 using GIS technology and verification with topographic maps and field inspections, instead of using the old inventory. The RID added the proportion fields as required structure and input other required data and information in the attribute tables from existing materials and reports.

Table 7: Update of the old GIS-based irrigation data by undertaking ground surveys

Schemes	Lao PDR	Viet Nam-Delta	Viet Nam-Highlands
Irrigation projects	• No change of spatial objects • Update attribute data based on ground surveys and participatory mapping		
Irrigation headworks	• Update the data for headworks including dam, weir, sluice, barrage and pumping from the updated data of DoI, provincial statistics, and ground surveys	• Update the data for small pumping mainly in Dong Thap, An Giang and Kien Giang • Update the new headworks type of sluice and barrage for the new construction during 2008-2012 • In total, update 1,511 irrigation headworks, including 761 main type B and W, which have with => 3 m. and 750 pump stations, which have areas greater than 100 ha	• Review and collect data and information of irrigation headworks constructed during 2008-2013 through the local surveys and participatory mapping with the local officers, operation and management staff • Examine some main headworks using hand-held GPS • In total, update 1,360 irrigation headworks constructed up to 2013
Irrigation areas	• Update the irrigated areas and crop calendar from the updated data of DoI, provincial statistics, and ground surveys	• Update the irrigated areas and crop calendar from the updated data of SIWRP, provincial's statistics, and ground surveys	• Update the irrigated areas and crop calendar from the updated data of IWRP, provincial statistics, and ground surveys
Irrigation reservoirs	• Update the new reservoirs from the updated data of DoI, provincial statistics, and ground surveys	*n/a*	Update information of 670 reservoirs
Irrigation canals	*n/a*	Update irrigation canals for main and secondary type by ground survey	

For Cambodia, the national irrigation database was updated based on the most up-to-date and existing data. There is no field data collection.

For Thailand, since the existing MRC database combined many small-scale irrigation projects, which have not yet been constructed and with location errors, RID has newly and fully updated and conducted the new irrigation database of Thailand from the "Irrigation Area Investigation Project in Thailand", carried out during 2012–2013 using GIS technology and verification with topographic maps and field inspections, instead of using the old inventory.

6 Current Situation of the Irrigation System

Cambodia has 2,047 irrigation projects, which are under the Cambodian government (e.g. MOWRAM, PIS) and other international organizations (e.g. JICA, NWISP, and KOICA). The actual irrigable area with the maximum irrigation rice plantation cover is 254,205 ha in the wet season, 258,105 ha in the dry season, and 16,713 ha for the third season. The irrigation headworks (310) include various types, such as regulator, pump station, reservoir, and flood prevention devices. The existing irrigation areas for both wet and dry seasons cover 479,762 ha. There are 124 existing reservoirs listed in the database.

Lao PDR has 3,094 irrigation projects, which are managed at provincial and district level by Laos government authorities and provincial irrigation services. However, data is not collected and recorded for every province. The gravity type is the main type of diversion and conveyance system. The actual irrigation during the rainy season is 225,446 ha with the largest irrigated cropping areas of 221,133 ha. The possible irrigated area is usually based on the implementation of the annual plan because the observance of this locally is quite strict. The irrigation headworks (3,094) are usually located on the routes around the irrigation projects, and are mainly irrigation weirs (2,091) and pumping stations (566). The existing irrigation areas (234,086 ha) are also counted according to the irrigation projects because the Mekong Basin of Lao considers an irrigation project as one in the total irrigation zone, which is also a unit of existing irrigation area. In the Mekong Basin of Lao, the existing irrigation reservoirs are also counted according to size and storage capacity. There are 257 earth dams/ reservoirs constructed mainly for domestic water supply into irrigated areas by gravity system connected to canal lines. The total capacity of the dams and capacity for irrigation is 1,157,160 m3 and 863,889 m3, respectively. There is no existing irrigation canal feature in the database in the Mekong Basin of Lao and the National Working Group has not updated this feature.

Thailand reports 134 irrigation projects, which are mainly the gravity irrigation type (119), managed by the Royal Irrigation Department. These irrigation projects have the potential to benefit the actual irrigable area of 872,647 ha with the maximum irrigated rice plantation area of 551,821 ha in the wet season. The projects are mainly used for water storage purposes. The irrigation headworks (322) are usually located on the routes around the irrigation projects, and are mainly irrigation reservoir headworks. The existing irrigation areas cover 903,946 ha in northern and northeastern regions of Thailand in the Lower Mekong Basin. The existing irrigation reservoirs include 177 earth dams and 79 rockfill dams (256 in total) which are not only constructed for water storage but primarily used for flood control and domestic water supply as well. The total capacity of the dams and capacity for irrigation are 10,547,495 m3 and 6,381,524 m3, respectively. There is no data for existing irrigation canal features provided by the country.

In the Viet Nam Mekong Delta, the irrigation system is a complex set of dense river system, linked together, for water supply for irrigated areas and flood control. The irrigation system in the VMD is divided into 4 regions, 22 sub-regions and 120 irrigation zones based on the natural characteristics, orientation of socio-economic development, and land-use planning and management strategy as show in Figure 8.

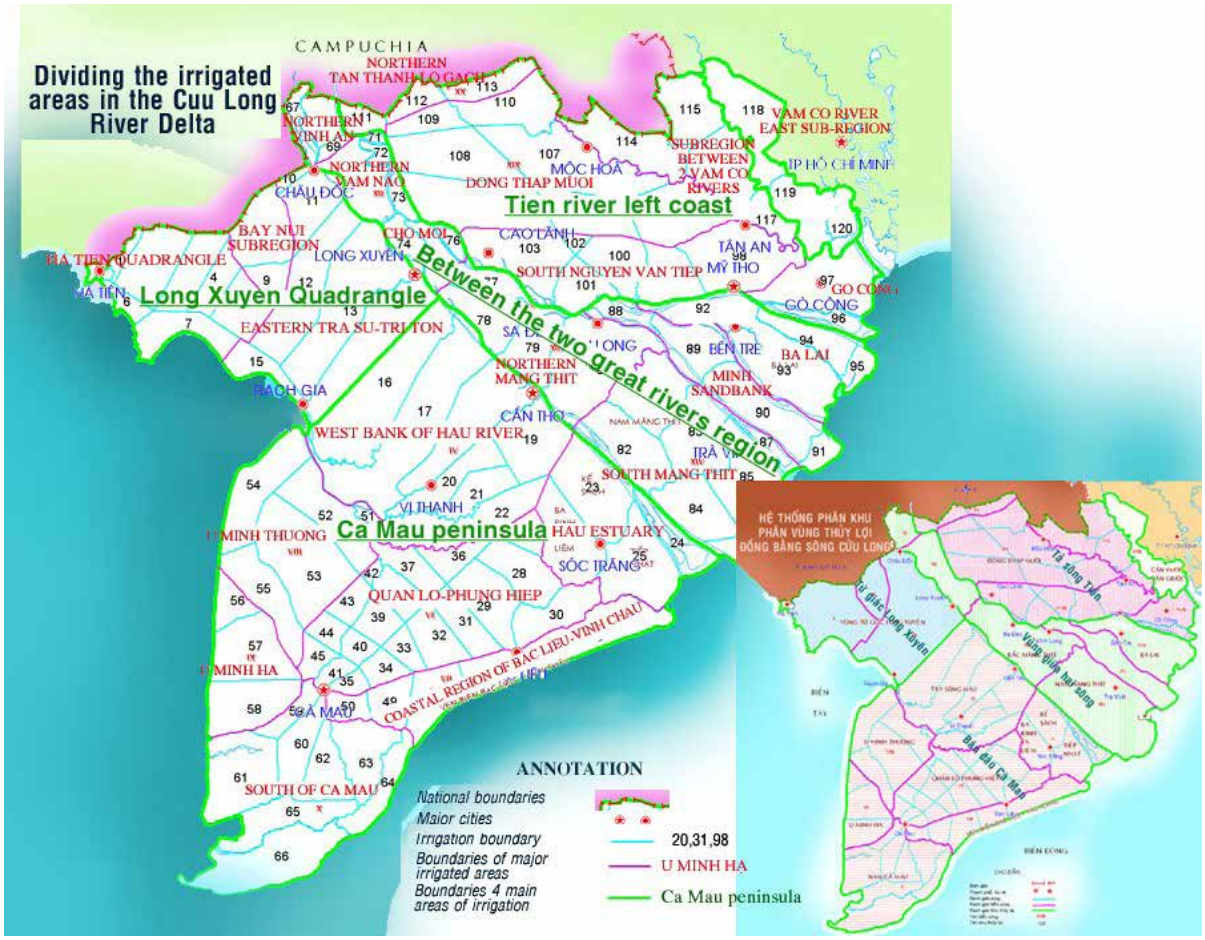


Figure 8: Irrigation system regions and zones in the Viet Nam Mekong Delta

For the Viet Nam Mekong Delta in the LMB, there are 107 existing irrigation projects managed by the Provincial Irrigation Work Exploitation Company, Division of Agriculture (or Economic Division) of Districts and the community, providing benefit for 1,993,725 ha of the actual irrigable area and 1,456,162 ha of the estimated maximum irrigable area for rice crops in the wet season. The irrigation system in the VMD has different functions that can be described in two main areas: *in flood-prone areas in the upstream region*, the major functions are flood control, water supply and containment of drainage, land improvement/alum control, protection of water sources, drinking water provision, and aquaculture (freshwater). *In the coastal saline area*, for saline control, the functions are drainage, water storage and water supply, protection of water resources, land reclamation/alum control, clean water provision and aquaculture (brackish water). The existing irrigation areas cover 3,452,451 ha. Some small lakes and reservoirs in the area are mainly used for serving daily life and tourism but are negligible for irrigation. The irrigation canal system in the delta are very dense and complex, approximately around 46,000 canals. For this project, only major canals for water supply and drainage are counted. Therefore, the national experts did not include the reservoirs for this study. There are about 5,625 earth canals with the total length of 13,410 km and 23,110 km for the main and secondary canals, respectively.

In the Viet Nam Highlands, the irrigation projects have constructed irrigation works at various levels. There are a total of 1,360 irrigation projects (1,341 of existing projects and 19 planned projects), which are used for water storage and managed by the Department of Agriculture

and Rural Development (DARD). The actual irrigable area in the wet season is 112,921 ha with the estimated maximum wet season irrigable area for rice crop of 47,001 ha. The situation of planning, funding, and investing in the project area has not been fully described due to many difficulties. There are 1,386 irrigation headworks including 714 pump stations, 658 weirs, and 14 barrages. The existing irrigation areas (112,921 ha) are also counted according to the irrigation projects as in Lao PDR. There are a total of 670 dams/reservoirs from small to large scale, including mainly earth dams (643) and other types (e.g. rockfill and concrete dams), with the functions of hydropower, irrigation, and domestic use. The total capacity of the dams and capacity for irrigation is 4,744 million m^3 and 4,133 million m^3, respectively. There are about 389 canals with the total length of 361.12 km in the study area, including earth and line canals.

The summarization of key information of each irrigation scheme in each Member Country is shows in ***Table 8. Figures 9 – 12*** show the improved irrigation database, including four layers, which are irrigation projects, headworks, areas, and reservoirs, in the GIS environment. Each layer has both spatial data, which is data that can be mapped and has information about the locations and shapes of geographic features and the relationships between them, and attribute tables, which are tabular containing information of a set of spatial features joined to spatial data layers. The maps of the irrigation database in the LMB are shown in ***Figures 13 – 15***.

Table 8 Summary of key information for irrigation schemes in each MC.

Irrigation schemes		Unit	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Irrigation project							
	Number of irrigation projects		2,047	3,094	134	120	1,360
	[1]Irrigation system type		N/A	G(2,553); P(175); E(319); D(47)	G(119); P(3); E(9); F(3)	D(76); L(44)	G(1,296); P(64)
	Responsible agency		Cambodian government (e.g. MOWRAM, PIS) and other international organization (e.g. JICA, NWISP, and KOICA)	Lao Government, Provincial Irrigation Service (PIS), and others (e.g. UNDP, EU, Luxembourg, ADB, Japan, etc.)	Royal Irrigation Department (RID)	Irrigation system company, Department of Water Resources	Department of Agriculture and Rural Development (DARD)
	Project status		E(2,005); P(30), Not identified (12)	Existing(3,090); Plan(3); Not identified (1)	Existing(134)	Existing(120)	Existing(1,341); Plan(19)
	Actual irrigable area in wet season	ha	254,205	225,446	872,647	3,315,511	112,921
	Estimated maximum wet season irrigable area for rice crop for planned irrigation project	ha	N/A	221,133	551,821	4,005,930	47,001
	Year of data collection		2015	2014	2014	2013	2013

1 Irrigation system type: G-Gravity; P-Fixed pump; E-Fixed Electric Pump; D-Fixed Diesel Pump; F-Flood retention; L-Tidal Irrigation

Irrigation schemes		Unit	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
	Project function		N/A	Aquaculture (Freshwater)		Drainage, water supply, salinity control, aquaculture (fresh and brackish water)	Water supply(1,310); Hydroelectricity(9); Not identified (41)
Existing irrigation headwork							
	Number of existing headworks		310	3,094	322	1,511	1,358
	[2]Type of headwork		P(20); R(25); D(115); W(47); O(103)	P(566); R(259); W(2,091); D(128); O (50)	P(37); R(259); W(19); B(2); D(4); O(1)	P(750); W(747); B(Barrage)	P(72); R(670); W(616)
Existing irrigation area							
	Number of irrigated areas		326	3,441	287	120	1,360
	Existing irrigated area in wet season	ha	479,762	238,019	903,946	2,269,148	112,921
Existing irrigation reservoir							
	Number of dams/reservoirs		124	257	256	No irrigation reservoir	670
	[3]Structural type		N/A	ED-Earth dam	ED(177); ZF(79)	No irrigation reservoir	ED(643); ZF(5); CN(5); Not identified(17)
	Active total capacity	1000m3	N/A	1,157.156	10,547.495	No irrigation reservoir	4,743.701
	Active capacity for irrigation	1000m3	N/A	863.889	6,381.524	No irrigation reservoir	4,132.606

2 Headwork type: n, R-Reservoir, W-Weir, B-Barrage, D-Division gate/regulator, O-Others

3 Reservoir Structural type: ED-Earth dam, ZF-Rockfill or Zoned Fill dam, CN-Concrete dam, CM-Composite dam

Irrigation schemes		Unit	Cambodia	Lao PDR	Thailand	Viet Nam-Delta	Viet Nam-Highlands
Existing irrigation canals *(Optional)*							
	Number of canals		Incomplete	Not collected	Not collected	5,652	389
	Total length of the main canals	km	Incomplete	Not collected	Not collected	13,410	361.12
	Total length of the second canals	km	Incomplete	Not collected	Not collected	23,110	N/A
	Structural type		Incomplete	Not collected	Not collected	Earth canal	E(20); L(257); Not identified (112)

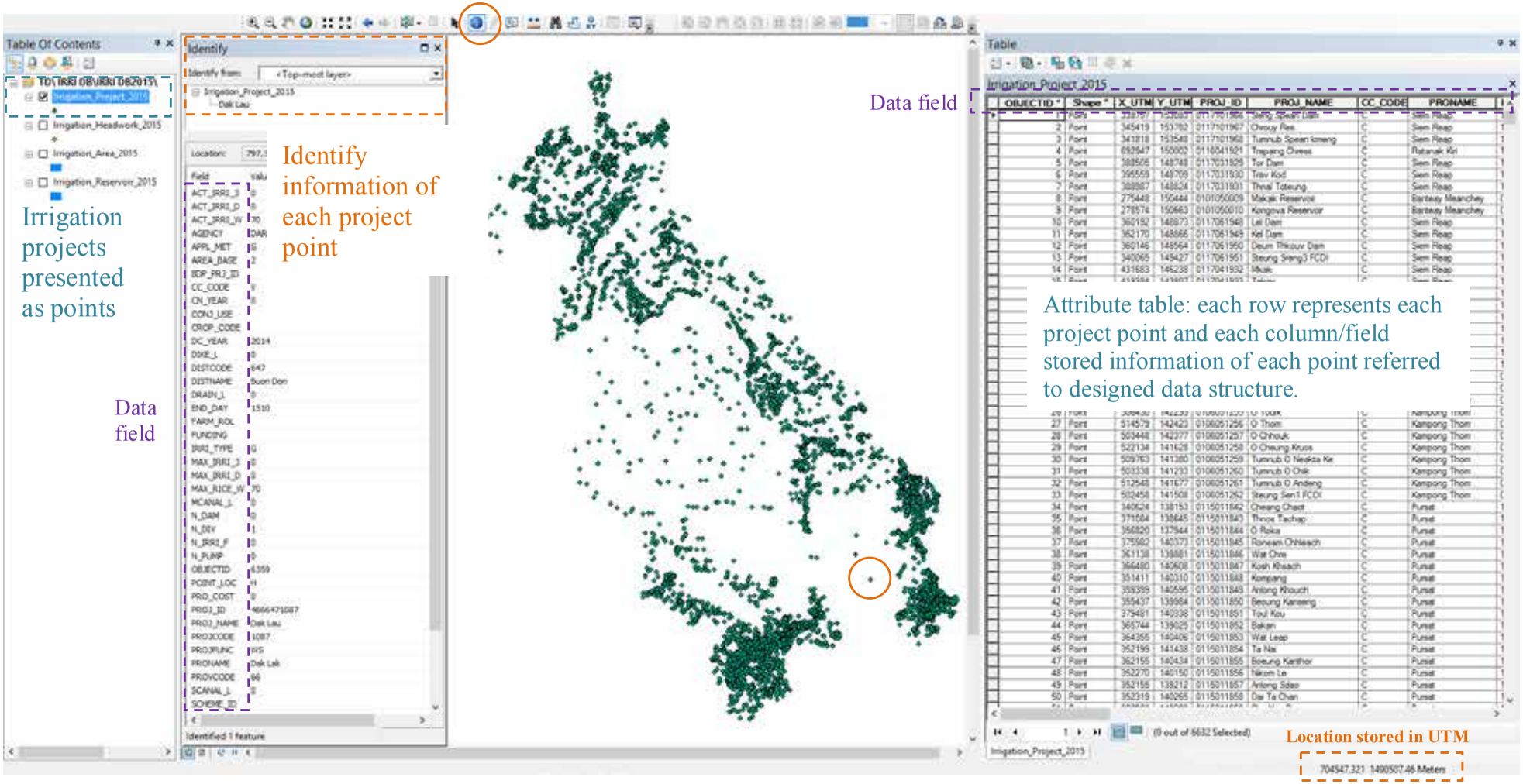


Figure 9: Spatial data, attribute table, and identified information for irrigation project layer

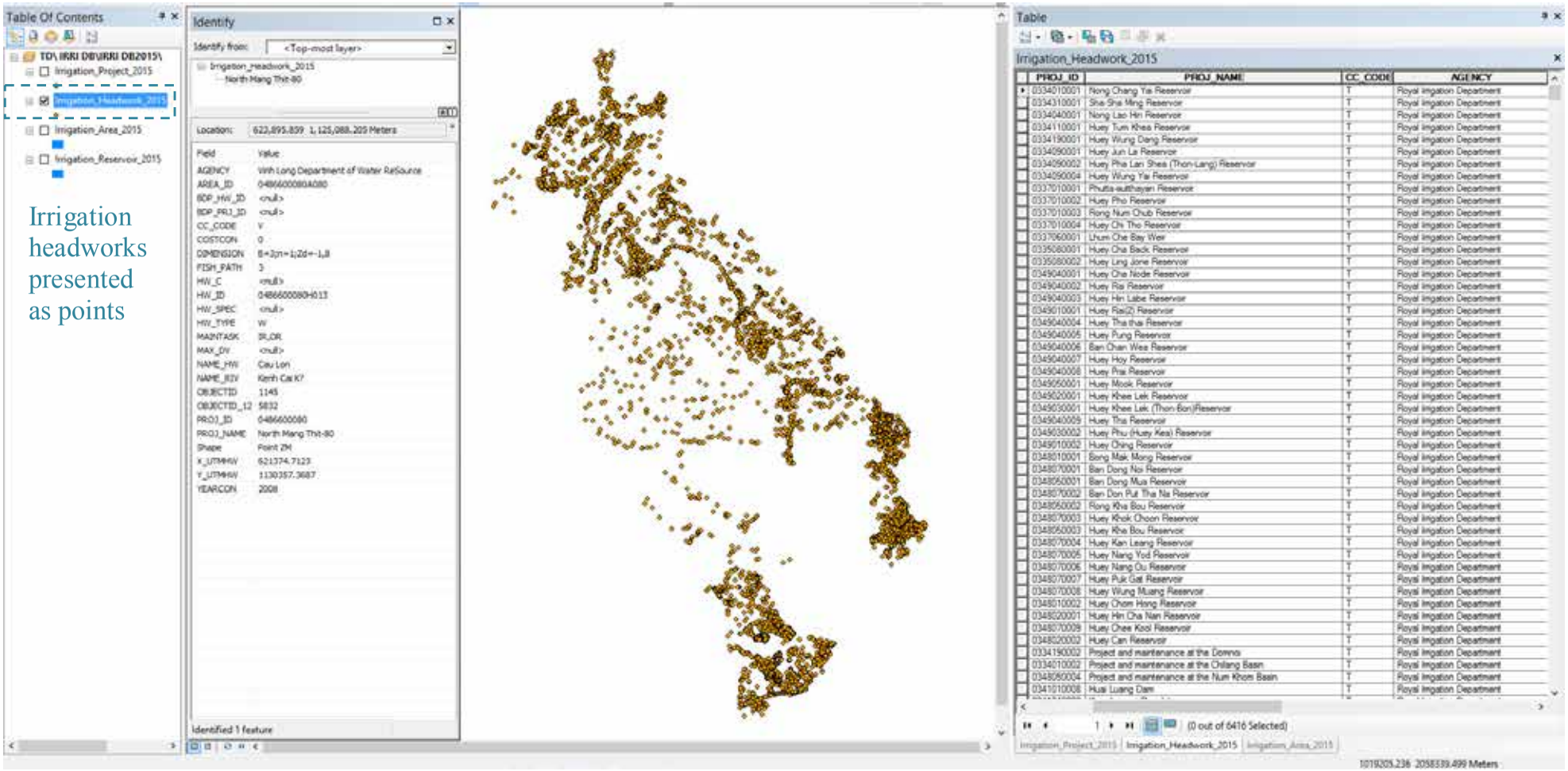


Figure 10: Spatial data, attribute table, and identified information for irrigation headwork layer

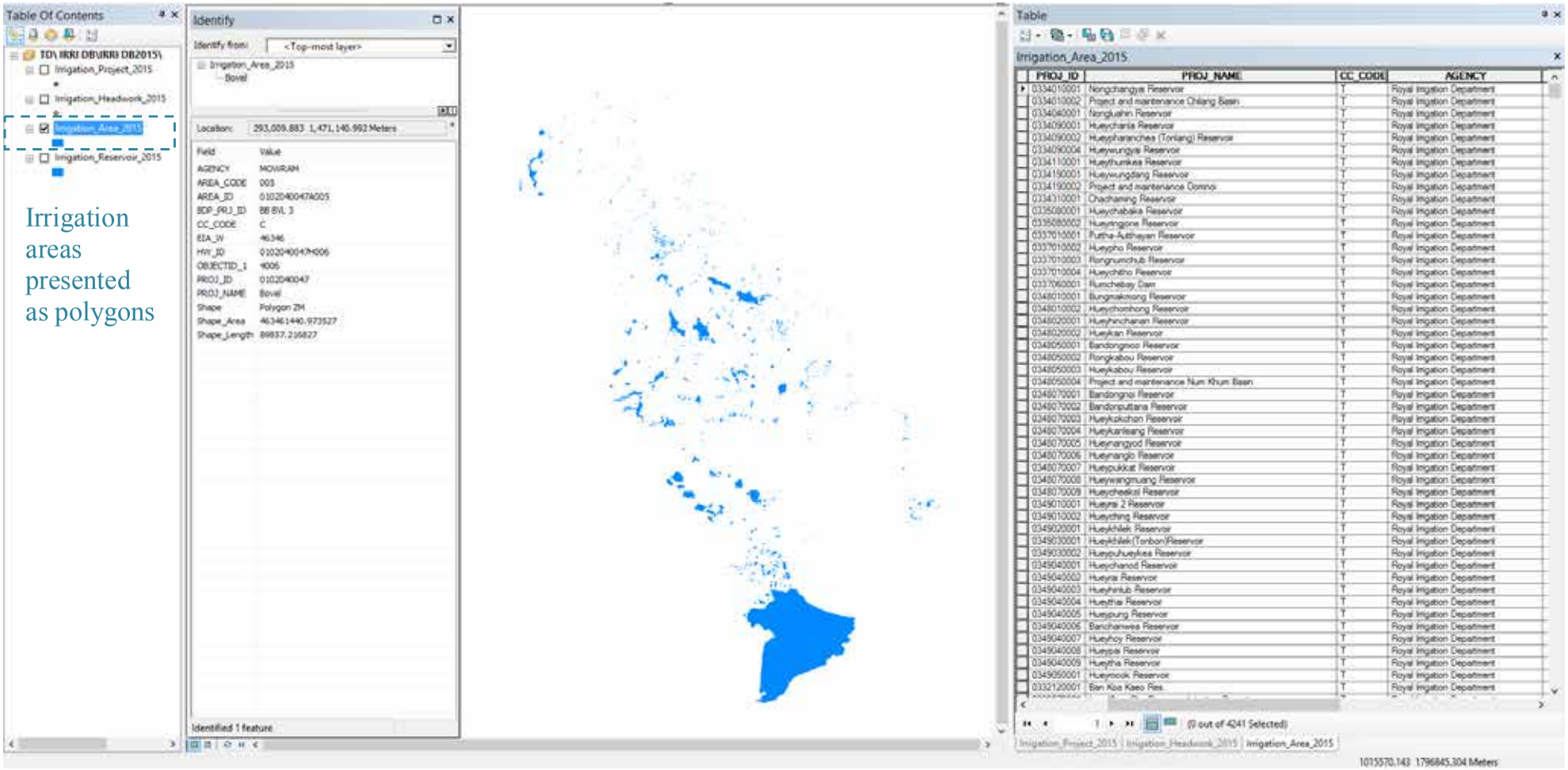


Figure 11: Spatial data, attribute table, and identified information for irrigation area layer

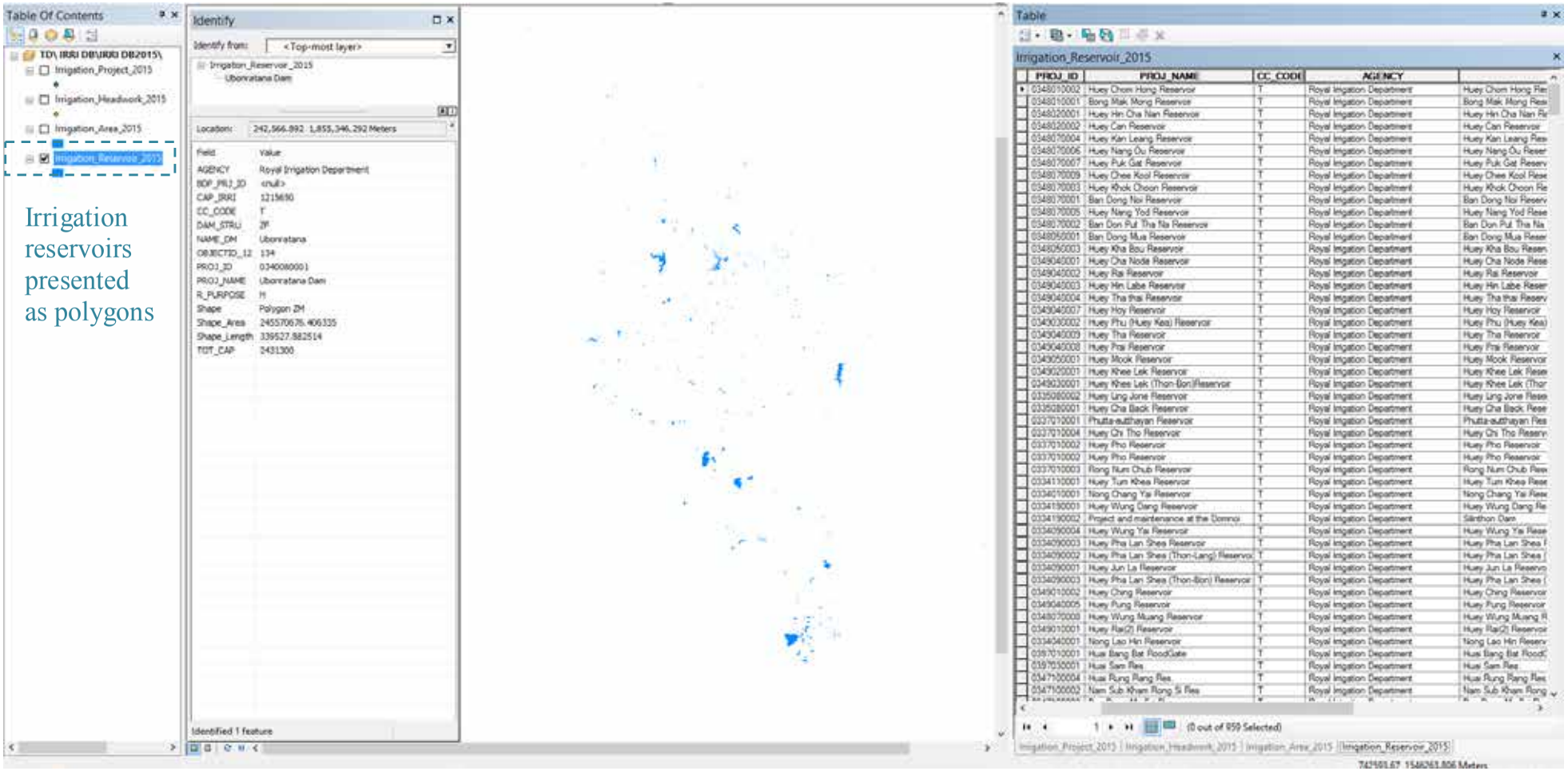
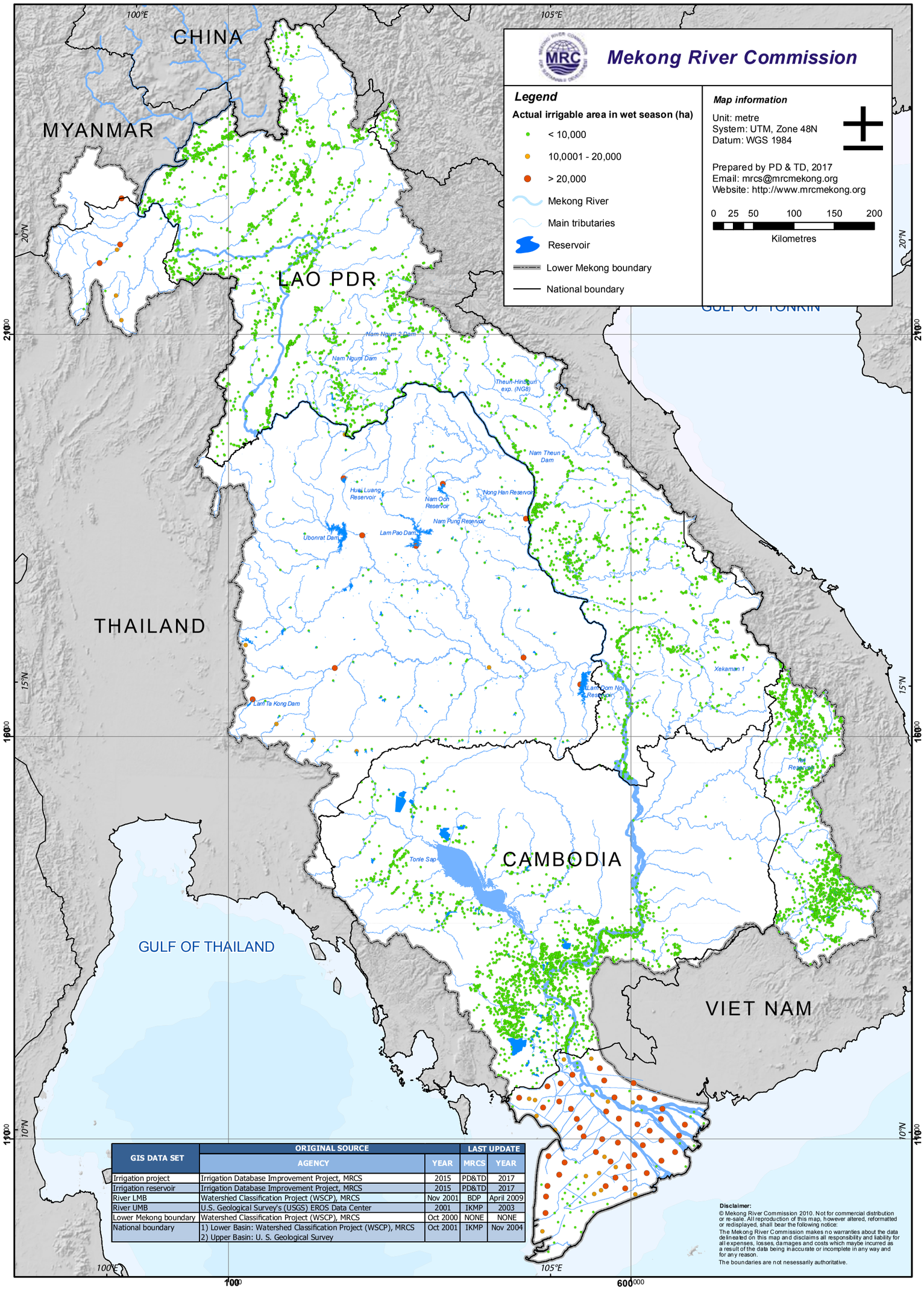


Figure 12 Spatial data, attribute table, and identified information for irrigation reservoir layer

Figure 12: Spatial data, attribute table, and identified information for irrigation reservoir layer

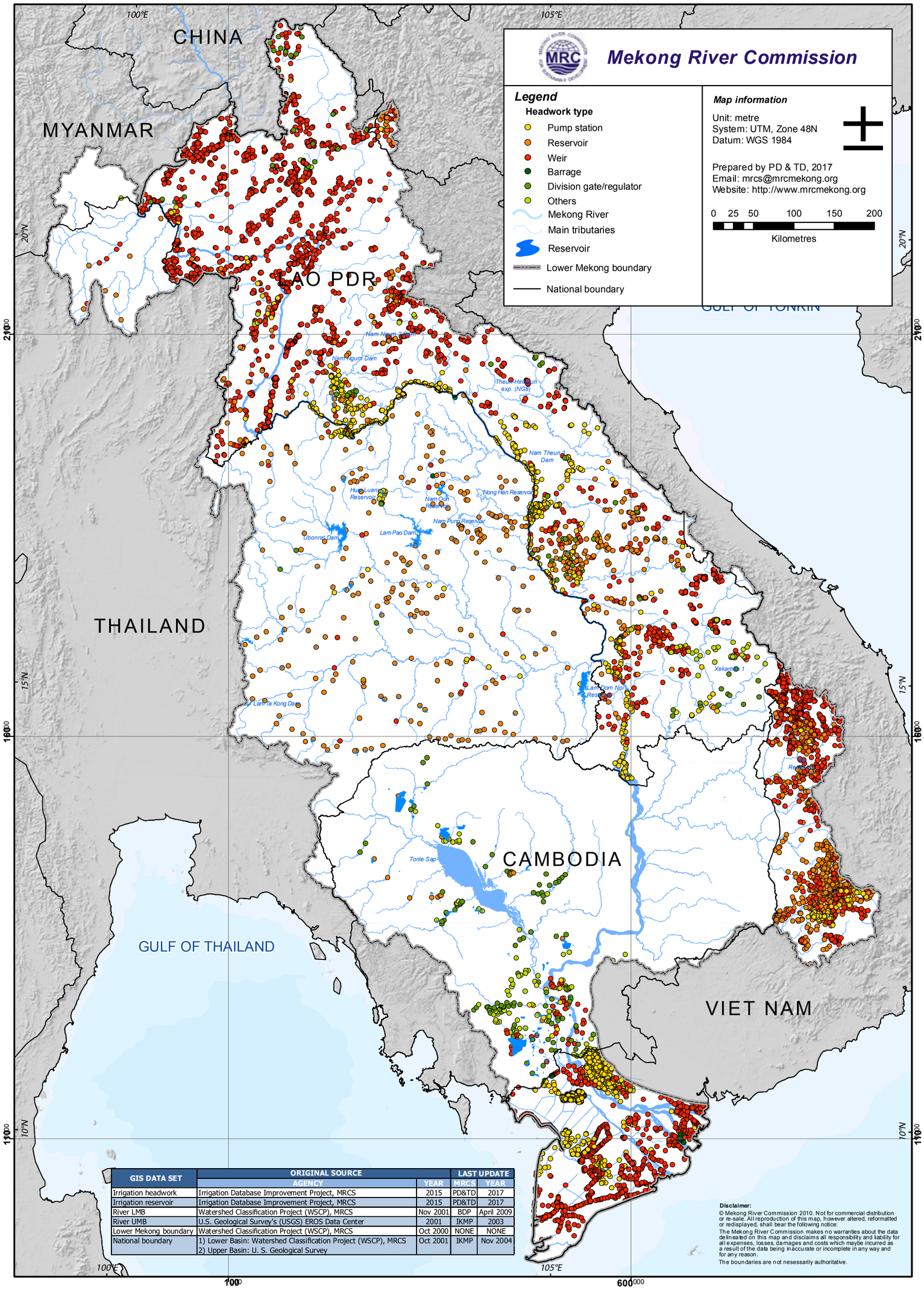
Irrigation projects and existing irrigation reservoirs



GIS DATA SET	ORIGINAL SOURCE		LAST UPDATE	
	AGENCY	YEAR	MRCS	YEAR
Irrigation project	Irrigation Database Improvement Project, MRCS	2015	PD&TD	2017
Irrigation reservoir	Irrigation Database Improvement Project, MRCS	2015	PD&TD	2017
River LMB	Watershed Classification Project (WSCP), MRCS	Nov 2001	BDP	April 2009
River UMB	U.S. Geological Survey's (USGS) EROS Data Center	2001	IKMP	2003
Lower Mekong boundary	Watershed Classification Project (WSCP), MRCS	Oct 2000	NONE	NONE
National boundary	1) Lower Basin: Watershed Classification Project (WSCP), MRCS 2) Upper Basin: U. S. Geological Survey	Oct 2001	IKMP	Nov 2004

Figure 13: Irrigation projects and existing irrigation reservoirs

Existing irrigation headworks and reservoirs



GIS DATA SET	ORIGINAL SOURCE		LAST UPDATE	
	AGENCY	YEAR	MRCS	YEAR
Irrigation headwork	Irrigation Database Improvement Project, MRCS	2015	PD&TD	2017
Irrigation reservoir	Irrigation Database Improvement Project, MRCS	2015	PD&TD	2017
River LMB	Watershed Classification Project (WSCP), MRCS	Nov 2001	BDP	April 2009
River UMB	U.S. Geological Survey's (USGS) EROS Data Center	2001	IKMP	2003
Lower Mekong boundary	Watershed Classification Project (WSCP), MRCS	Oct 2000	NONE	NONE
National boundary	1) Lower Basin: Watershed Classification Project (WSCP), MRCS 2) Upper Basin: U. S. Geological Survey	Oct 2001	IKMP	Nov 2004

Figure 14: Existing irrigation headworks and reservoirs

Existing irrigation areas

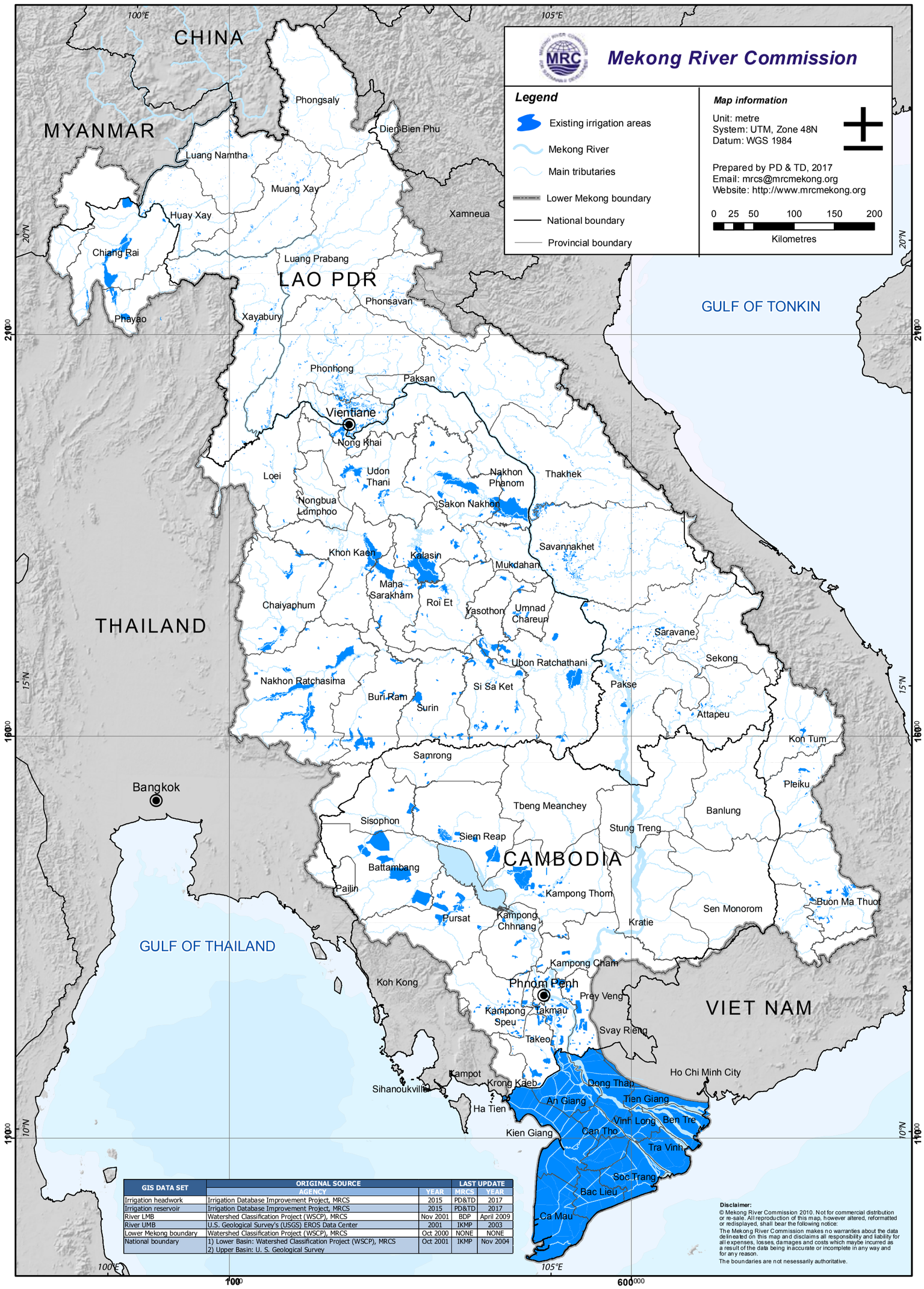


Figure 15: Existing irrigation areas

7. Quality Assurance/Quality Control (QA/QC)

Quality Assurance (QA) is the planned and systematic production processes that provide adequate confidence in a product's suitability for its intended purpose. It is a well-recognized approach to establishing the level of accuracy that can be expected from a dataset. This level of accuracy gives users confidence in the dataset to decide whether it is appropriate for their purposes. QA/QC is the combination of quality assurance, the process or set of processes used to measure and assure the quality of a product, and quality control, the process of ensuring products and services meet consumer expectations.

7.1 Quality Assurance Implementation

This chapter sets out procedures for Quality Assurance (QA) to be applied to data prior for updating databases in MRC Information System (MRC-IS), including the Knowledge Base (KB) of the MRC Decision Support Framework (DSF). The procedures are in two parts covering Administrative Arrangements and Technical Arrangements. The technical arrangements are based on current practice in the Technical Support Division (TD) for spatial and image data; on the checks found necessary on other data during the course of Water Utilization Project Component A: Development of Basin Modelling Package and Knowledge Base (WUP-A); and on experience of likely sources of error gained through other similar projects. All datasets are subject to errors of one sort or another and the minimization of errors can be a time-consuming and costly business. Complete elimination of errors is statistically a highly improbable outcome of any data cleaning exercise. Modern planning techniques therefore are based on an assumed level of accuracy. QA is a well-recognized approach to establishing the level of accuracy that can be expected from a dataset and therefore an indication of the confidence that can be placed in the estimates based on those data.

7.1.1 Administrative Arrangements

The underlying QA concept set out in these procedures is that data should be subjected to QA procedures at source. Correction of errors and exercises, such as gap-filling, should be undertaken by those with expertise in the relevant fields. As described in the MRC Operational Data Delivery Procedures, the assigned primary custodians are responsible for undertaking quality assurance of its own data prior to its delivery to the MRC Secretariat (MRCS). However, MRCS, as the custodian of the MRC-IS, is also responsible for undertaking quality assurance of all data included in the MRC-IS together with any rectification of errors as may be found necessary.

The responsibility of the MRC-IS custodian is to ensure that only data that has already been checked in accordance with approved QA procedures are loaded into the MRC-IS databases, including the Knowledge Base. The MRC-IS custodian should determine whether the level of accuracy is sufficient for the purposes that it is intended, as necessary in consultation with the end-users (e.g. MRC Programmes such as BDP and EP). If the level of accuracy is found to be insufficient, it would be appropriate for the MRC-IS custodian to improve the datasets (e.g. by gap-filling) before loading them into the MRC-IS. Such improvements are not covered by these procedures.

To manage data effectively as well as to ensure the quality of data, roles and responsibilities of all concerned parties must be clear. This section describes the administrative arrangements

associated with assuring the quality of data held in the MRC-IS databases, either delivered to MRCS from a Primary Custodian or collated, collected or otherwise obtained through an MRC Programme or Project.

- Primary Custodians
- As described in the MRC Operational Data Delivery Procedures, the assigned primary custodians are responsible for undertaking quality assurance of its own data prior to its delivery to the MRC Secretariat. A description of data quality should be included in the metadata accompanying each dataset delivered to the MRCS.
- MRC Programmes and Projects
- Data and information is collected by MRC Programmes and Projects for various purposes and intended uses. Prior to start-up of data collection activities, the Programme or Project shall appoint a Data Custodian responsible for the contents and metadata of collected data, and for carrying out quality assurance. All QA activities undertaken shall follow these procedures.

7.1.2 Technical Arrangements

The Technical Arrangements for Quality Assurance cover two main types of data that are part of the MRC-IS databases: spatial data (including both maps and images) and non-spatial data (e.g. time-series and socio-economic data).

All data held in the MRC-IS needs to be accompanied by a set of metadata. Metadata generally describe what the information in the dataset is, where it has come from and in what form it has been stored. This serves three main purposes. Firstly, it enables users of the data to check back when the data appears to indicate unusual results. Secondly, it is a means of recording changes made to the datasets as may happen from time to time, thus warning users that values may have been adjusted. Thirdly, and importantly, the metadata provides an early indication to the experienced user of the reliability of the information. The arrangements specify the information required to be stored for each dataset in the three categories of data.

Quality Assurance procedures must also cover a range of standard checks on the data to establish the general level of accuracy and reliability of the information held in the datasets. These checks are designed to cover different aspects of the data, typically:

- Referencing system, units, and terminology
- Arithmetic correctness
- Internal consistency and completeness
- Consistency with other relevant information
- The check-lists provided set out the different checks to be undertaken, key considerations when evaluating the data, and examples of where errors may arise.

7.2 Quality Control Process

Quality control (QC) is a process by which entities review the quality of all factors involved in production. It is a set of activities for ensuring quality in products. The activities focus on identifying defects in the actual products produced.

The principle goals of QA/QC are:

- To ensure the level of accuracy for all published datasets. Relationship to the reality
- To ensure the quality for all published datasets
- To validate the usability of the data
- To enforce metadata adherence
- To enforce specialized conformity that might exist in the data, such as directionality connectivity, and topology

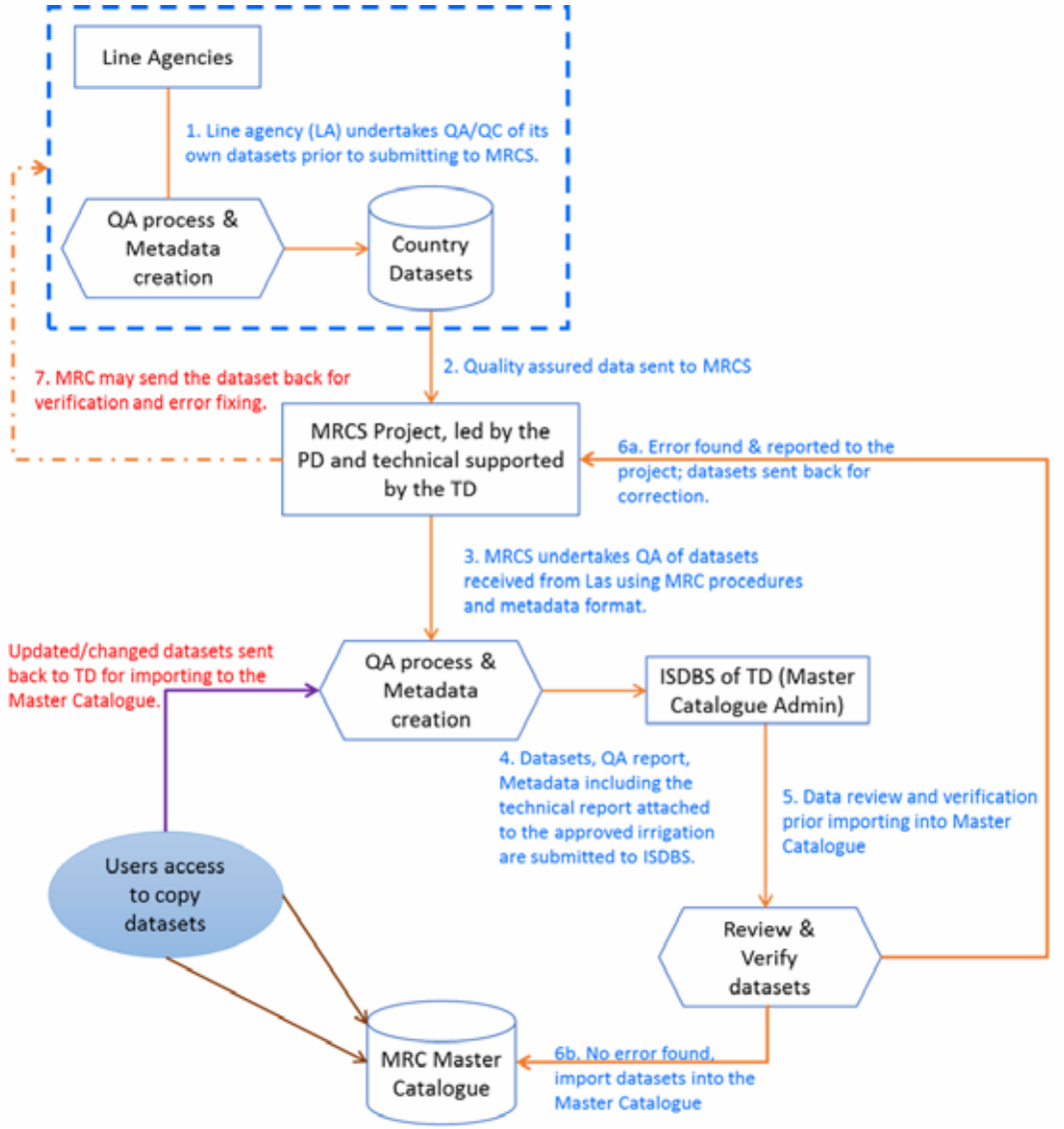


Figure 16: Flow chart of QA/QC

From Figure 16, data are mainly produced by the primary custodians or line agencies of the four riparian states. In principal, when establishing the project, which involves data collection and production, QA/QC should be established and implemented as part of the project. In fact, quality checks should be done from time to time during the data creation/collection process to ensure accuracy is within the level of acceptance. Level of acceptance refers to the accuracy of data that meet the project standard or criteria for purpose of usage. International standards, such as mapping accuracy, could also be applied to control the quality of data. The following table shows the commonly accepted and used map accuracy standards.

Table 9: Minimum Map Unit

Map Scale	Meters at Map Scale	Millimeters on Paper
1:10,000	8	0.8
1:50,000	25	0.5
1:100,000	50	0.5
1:250,000	125	0.5
1:500,000	250	0.5

Source: United States Geological Survey (USGS) Map Accuracy Standards (95 % Circular Horizontal Error)

7.3 MRC QA Procedures

MRC QA Procedures include the quality assurance checklist to be considered when performing quality assurance on datasets. This checklist is based on the following aspects:

- **Completeness** – Completeness is the adherence of the data to the database design. This means that all the data conforms to a known standard for topology, table structure, precision, projection, and other data model specific requirements.
- **Validity** – Validity is a measure of the attribute accuracy of the database.
- Each attribute must have a defined domain and range. The domain is the set of all legal values for the attribute. The range is the set of values within which the data must fall.
- **Logical consistency** – Logical consistency is a measure of interaction between the values of two or more functionally related attributes.
- **Physical consistency** – Physical consistency is a measure of the topological correctness and geographic extent of the database. For example, the requirement that all electrical transformers in an electrical distribution database's GIS have annotation denoting phasing placed within fifteen feet of the transformer object is one that describes a physical consistency spatial requirement.
- **Referential integrity** – Referential integrity is a measure of association of related tables based upon their primary and foreign key relationships. Primary and foreign keys must exist, and they must associate sets of data in the tables given predefined rules for each table.
- **Positional accuracy –** Positional accuracy is a measure of how well each spatial object's position in the database matches reality. Positional error can be introduced in many

ways. Incorrect cartographic interpretation, through insufficient densification of vertices in line segments, or digital storage precision inadequacies, are just a couple sources of positional inaccuracies. These errors can be random, systematic, and/or cumulative in nature. Positional accuracy must always be qualified because the map is a representation of reality.

There are two major categories of QA – Visual and Automated QA.

1) Visual QA – is visual inspection on a dataset. Existing paper maps were scanned and saved as digital files, which were then used as base maps for preliminary feature quality checks. Random error checks on attributes were also performed. When doing visual QA, checks may be carried out on:

a. Metadata – Before doing anything with the data, you might want to check first if the dataset received has the accompanied metadata and if metadata follows the MRC guidelines or format.

b. Geographic feature definition – terminology and classification.

c. Checking Geodetic datum and map projection from data property information or check against the geo-referenced scanned map or dataset of the same coordinate system.

d. Topological consistency with relevant information

e. Geographic feature completeness

f. Positional accuracy – the closeness of locational information compared to the based map (scanned map).

g. Spelling correctness of attribute values

2) Automated QA – This uses a query function to check errors in the data, especially errors in attribute values. The following could be looked at:

a. Referential integrity and coding system – check relational integrity of two tables by detecting unmatched relationship keys between two tables in a JOIN – an automated function to combine 2 tables together by using the primary keys for linkage.

b. Attribute consistency with official records – check inconsistencies in how values were stored (e.g. place names are stored using all capital letters and mixed lower-upper case.)

c. Attribute accuracy –

i. Range of attribute values/correctness of values – Detect out-of-range values based on pre-defined ranges (minimums and maximums) to ensure that all values in the field are within the defined range.
ii. Detects non-unique values for a column that is being used as a primary key and that requires no duplicate.
iii. Detects invalid values based on pre-defined lists of valid values to ensure that the column/field contains only valid values.
iv. Detects other than the specific value to ensure that all values in the test column are equal to the specific values
v. Detects NULL, blank and/or zero values for a test field.
vi. Detects values that do not conform to the specified format (lower-case, upper-case, numeric, non-numeric); e.g. if format was set to lower-case then the upper-case type values are errors.

vii. Detects values that are not in the defined column length, e.g. values that have lengths longer than the specified length of columns which cause missing information.

d. **Attribute completeness** – checking empty records or missing records in the table.

e. **Attribute structure** – checking for unmatched structure with the design or inappropriate structure.

7.4 Review of database checks

The Quality Assurance and Quality Control process was operated to follow MRC QA Procedures. The main task is to check graphic errors by applying the topology check (relational database check) as well as spelling check (attribute or tabulate data check). Due to the irrigation project and the headwork being point features, they were collected from NMCS and LAs. Hence, MRCS assumes that they were located into the correct position, correct side of the road or canal, and therefore MRCS did not check the positional accuracy because of lack of base map for reference.

For the graphic check, the topology rules were applied to both polygon (area) and line (arc) with Logical consistency, Physical consistency, and Positional accuracy concept. The polygon feature datasets applied the typology rules: that they should not overlap and that they should not have gaps. Also, the line feature datasets applied the typology rules: they must not have pseudo nodes and must not self-intersect. These rules were applied because the line feature represents the canal dataset that indicates the characteristic of discharge and water flows. Hence, the reference node would be the starting point of each line feature (canal), because it affects the relational direction of water flows. If the lines have pseudo nodes, it means that line has error for the relational database and the Logical consistency for the real flow of water is not applicable. The topology checking is useful for the end-users to calculate the direction of flow accumulation and the capability of the reservoir area.

7.5 Quality assurance checklist

7.5.1 Spatial Data

The following checks are to be made on all spatial data, e.g. vector and raster data and satellite imagery, prior to updating any MRC-IS database.

	Theme	Check	Key considerations	Examples
1	Metadata	1.1 Properly documented data	As described in MRC-IS Metadata Standard	
2	Feature definitions	2.1 MRC accepted terminology	Check that the features shown are consistent with those definitions in use by MRC	*Tributary maps match the definition of tributaries agreed by MRC*
		2.2 MRC accepted classification systems	Check that the features shown are consistent with the classification systems in use by MRC, or that MRC accepts new classifications	*Land-use classes match those used for MRC planning purposes*
		2.3 Classification completeness	Check whether classification covers all possible classes	*Land use polygon with unidentified class*

	Theme	Check	Key considerations	Examples
3	Geodetic datum and map projection	3.1 Consistency with existing spatial data presentations	Check source records for map projection	
			Check overlay of new data at basin-level to ensure adequate match with known features of existing data	
4	Topology	4.1 Consistency with existing spatial data presentations	Check overlay of new data in sample locations to ensure adequate match with known features of existing data	*Match between urban and rural centres with road and river networks*
		4.2 Closed polygons	Check at sample locations that polygons are closed	*Tributary bank lines do not define river area properly*
		4.3 Unbroken networks	Check at sample locations that networks are fully connected where needed	Line diagrams of IQQM network
		4.4 Completeness of data records	Check that the dataset is complete without apparent missing records, and that if missing, the dataset is appropriately annotated	*Major urban centres missing from urban centres dataset*
5	Positional accuracy	5.1 Identification of gross geo-referencing and/or coding errors	Visual inspection at basin-level of (selected parts) of themes to identify outliers	*Points located outside LMB*
				Points grouped by country occurring in wrong country
		5.2 Consistency with existing spatial data presentations	Check overlay of new data in sample locations to ensure adequate match with known features of existing data	*Gauging stations located alongside rivers*
6	Attribute data	6.1 Accepted spelling	Check that the names used are consistent with MRC accepted spelling (nb DSF allows for aliases to be used in the case where country or agency spelling differs from that adopted by MRC)	*River and gauging station names*
		6.2 Accepted referencing and/or coding	Check that the names used are consistent with MRC accepted referencing systems as may be defined or as are in common use	*Hydromet station referencing system*
		6.3 Consistency with official records	Check that the areas of polygons match the official records to within an acceptable tolerance	*District areas computed from polygons differ from Government records by more than 5%*
			Check that administratively important boundaries match the official records to within an acceptable tolerance	*National boundaries are in the right place at reasonable resolution*
		6.4 Completeness	Check for unfilled records or missing values	
		6.5 Accepted structure	Check whether attribute structure matches the database design	

7.6 QA/QC Result for Cambodia

The Cambodia irrigation databases were generated from existing databases of the Council Study project. Hence, the schema and data structure are rather different from the irrigation database of other Member Countries. The irrigation database from Cambodia consists of; 1) Irrigation Areas, 2) Irrigation Headworks, 3) Irrigation Projects, and 4) Irrigation Reservoirs. From the first QA /QC result – found 436 overlapped area errors and several gaps in the irrigation area dataset with several attribute errors such as the field name HW_ID, AREA_ID, EIA_ID, etc. In addition, there are many inconsistent field names as well as missing data in several field names from attribute checks.

This QA /QC result – found 436 overlapped areas with 333 gap errors in the irrigation area dataset; found 37 overlapped areas with 135 gap errors in the reservoir dataset. Those errors need to be fixed for data correctness and completeness. The remaining datasets have no critical mistakes to be corrected. The detailed errors – either topology or attribute errors – are shown in Table 10 and Figures 17 to 20, respectively.

In addition, this QA/QC process also found 3 main errors for 2 datasets; irrigation areas, and reservoirs. The irrigation areas and the reservoirs datasets have 2 main errors, either the gap or overlapped polygon. Even though these errors are the small polygon, they need to be carefully fixed for data correctness and completeness. The detailed description of topology rules and the possible method to correct the datasets are shown in Tables 17 to 19.

Table 10: Summary of the errors found in the Cambodia Datasets

Dataset	Rule Check	Topology Result	Recommendation	Attribute Check
Irrigation Areas	• Must Not Overlap	• Found 436 errors	• Need to fix the errors	• Disappear Field name: HW_ID, AREA_ID, EIA_ID
	• Must Not Have Gaps	• Found 333 errors	• Need to fix the errors. It's the same area of the overlap errors.	• Incomplete data in field "PROJ_NAME"
Irrigation Reservoirs	• Must Not Overlap	• Found 37 errors	• Need to fix the errors	• Incomplete data in field "PROJ_NAME" and "PROJ_ID"
	• Must Not Have Gaps	• Found 135 errors	• Need to fix the errors	• Disappear Field name: CC_CODE, AGENCY, NAME) DM, DAM_STRU, R_PURPOSE, TOT_CAP, CAP_IRRI (Attribute is inconsistent with the IRR Project)
Irrigation Headworks	• Must Be Properly Inside	• *Found 231 from 340 headwork locations are outside irrigation area*	• *Headworks can be either on canals or on the ground, so just check the position of HW must be inside irrigation area. This error may not need to be fixed but applied for checking concerns*	• Field Name "PROJ_NAME, AGENCY, HW_ID, HW_TYPE" are incomplete data
Irrigation Projects	• Must Be Properly Inside	• *Found 1,906 from 2,139 projects are outside irrigation area*	• *This error may not need to be fixed but applied for checking concerns*	• All filed names are inconsistent with the schema and data structure of irrigation database projects

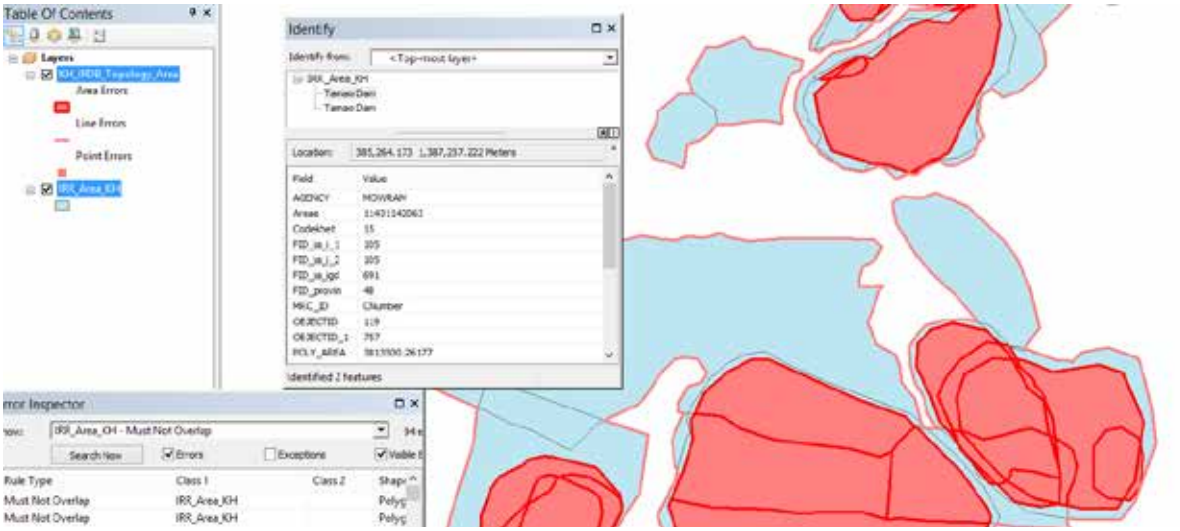


Figure 17: Overlap errors found in the Cambodia irrigation area dataset

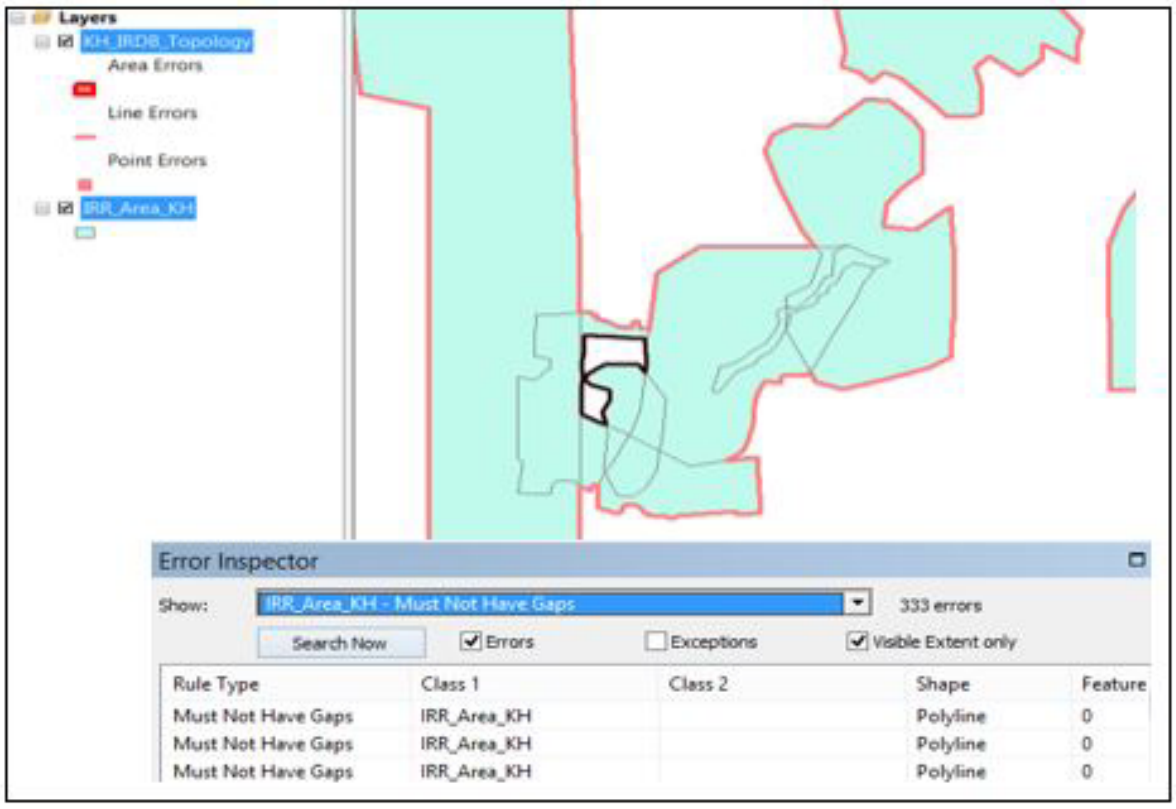


Figure 18: Gap errors found in the Cambodia irrigation area dataset

IRR_Reservoir_KH

REF	MRC_ID	PROJ_NAME	PROJ_ID	SHA_AREA	AGENCY	CCODE
0		Man made reservoir		168.17558	BDP2009	0
421	C421	Naktaror Res.	PS KRK 2	340.918581	MOWRAM	1
423	C423	O Ach Kok Res.	PS KRK 3	378.012499	MOWRAM	1
1116	C446	O Chom Norm Res.	TK PKB 2	359.291081	MOWRAM	0
0		O Chum Hydro reservoir		114.74277	BDP2009	0
1019	C522	O Treng Reservoir	KS KPS 3	1064.48623	MOWRAM	0
1019	C522	O Treng Reservoir	KS KPS 3	1.149156	BDP2009	0
585	C585	Pong Pous Reservoir	PV PSD 7	531.49753	MOWRAM	1
1074	C599	Preaktabak Res.	PS KRK 16	165.738581	MOWRAM	0
620	C620	Prek Chrach Res.	TK ABR 3	375.833683	MOWRAM	1
704	C704	Prey Mean Res.	TK SAM 7	314.635738	MOWRAM	1
705	C705	Prey Mean Res.	TK TRG 2	204.341313	MOWRAM	1
1114	C716	Prohas Kbal Reservoir	PS KVH 4	410.804501	MOWRAM	0
1114	C716	Prohas Kbal Reservoir	PS KVH 4	28.337322	MOWRAM	0
1114	C716	Prohas Kbal Reservoir	PS KVH 4	35.80844	BDP2009	0
726	C726	Purtamon Reservoir	PV MES 5	147.708911	MOWRAM	1
0		Reservoir		4836.458562	BDP2009	0
0		Reservoir		376.135207	BDP2009	0

FID_ia_i_2	OBJECTID	REF	MRC_ID	PROJ_NAME	PROJ_ID
292	350	10733	C150	Bovel	BB BVL 3
297	356	10605	C809	Srok Dam	SR KLH 4
-1	0	0		Spean Sreng	
-1	0	0		Ta Meng Reservoir	
-1	0	0		Ta Meng Reservoir	
297	356	10605	C809	Srok Dam	SR KLH 4
91	102	10625	C730	Ranim Pra Yal	BB MRS 3
292	350	10733	C150	Bovel	BB BVL 3
293	351	10731	C329	Kompeng Puey	BB BNA 4
294	352	10734	C877	Tahen	BB BVL 2
295	353	10730	C277	Kanghat	BB BNA 2
296	354	10729	C617	Prek Chik	BB MRS 5
0	0	0			
0	0	0			
0	0	0			
0	0	0			
0	0	0			
293	351	10731	C329	Kompeng Puey	BB BNA 4
295	353	10730	C277	Kanghat	BB BNA 2
295	353	10730	C277	Kanghat	BB BNA 2
295	353	10730	C277	Kanghat	BB BNA 2
295	353	10730	C277	Kanghat	BB BNA 2
296	354	10729	C617	Prek Chik	BB MRS 5
0	1	10770	C449	O Chrey flood dam	KC BTY 6
31	35	10379	C201	Chhey Thom	KD KKD 3

Figure 19: Spelling correctness of attribute values (attribute error found in the irrigation headwork of the Cambodia dataset)

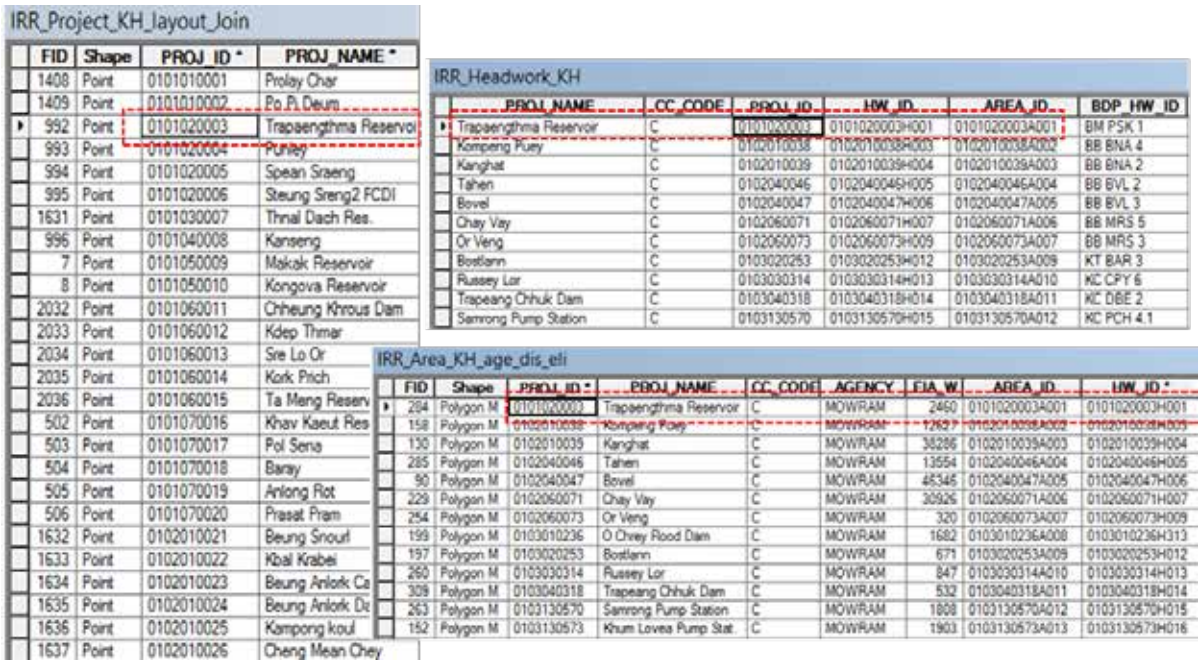


Figure 20: Key indexes generation for Cambodia

7.7 QA/QC Results for Lao PDR.

The irrigation database from Lao PDR consists of 4 datasets, namely: 1) Irrigation Areas, 2) Irrigation Headworks, 3) Irrigation Projects, and 4) Irrigation Reservoirs. From the first QA/QC result – there are 161 overlapped area errors in the irrigation area dataset with 3 overlapped areas. From the attribute error checking, several errors were found regarding the spelling correctness of attribute values. The detailed errors concerning either topology or attribute errors are shown in ***Table 11***.

Table 11: Summary of errors found from the first QA/QC in the Lao PDR Datasets

Dataset	Rule Check	Topology result	Attribute Check
Irrigation Areas	• Must Not Overlap • Must Not Have Gaps	• Found 161 overlapped area errors	• PROJ_NAME needs to have consistent spelling (H.xxx = Huay xxx?)
Irrigation Headworks	• Must Be Properly Inside	• *Found 3,071 from 3,162 headwork locations are outside irrigation area*	• PROJ_NAME and NAME_ is inconsistent alphabet (Capital Letter for the first one). And need to check the space from the spacebar press.
Irrigation Projects	• Must Be Properly Inside	• *Found 3,071 from 3,162 projects are outside irrigation area*	• PROJ_NAME has consistent alphabet (Capital Letter for the first one), And need to check the space from the spacebar press. • Check field name
Irrigation Reservoirs	• Must Not Overlap • Must Not Have Gaps	• Found 3 overlapped area errors	• PROJ_NAME needs to have consistent spelling (Ex: Na boum, Nam Hin... etc) • AGENCY Check consistent spelling (Lao or LAO) • NAME needs to have consistent spelling (H.xxx = Huay xxx?)

From the final QA /QC result, 20 overlapped areas with 1 gap error were found in the irrigation area dataset. Those 21 errors need to be fixed for data correctness and completeness. The rest of the datasets have no serious mistakes to be corrected or fixed. The detailed errors are shown in ***Table 12*** and ***Figures 21 to 22***.

Table 12: Summary of errors found in the Lao PDR Datasets

Dataset	Rule Check	Topology Result	Recommendation	Attribute Check
Irrigation Areas	Must Not Overlap	• Found 20 overlap errors	Need to fix the errors	No errors found
	Must Not Have Gaps	• Found 1 gap error	Need to fix this error. It's the same area as the overlap errors.	
Irrigation Reservoirs	Must Not Overlap	No errors found	No errors found	No errors found
	Must Not Have Gaps	No errors found	No errors found	
Irrigation Headworks	Must Be Properly Inside	• Found 3,071 from 3,162 headwork locations are outside irrigation area	• *Headworks can be either on canals or on the ground, so just check the position of HW is inside irrigation area. This error may not need to be fixed but applied for checking concerns*	No errors found.
Irrigation Projects	Must Be Properly Inside	• Found 3,071 from 3,162 projects are outside irrigation area	• *This error may not need to be fixed but applied for checking concerns*	No errors found

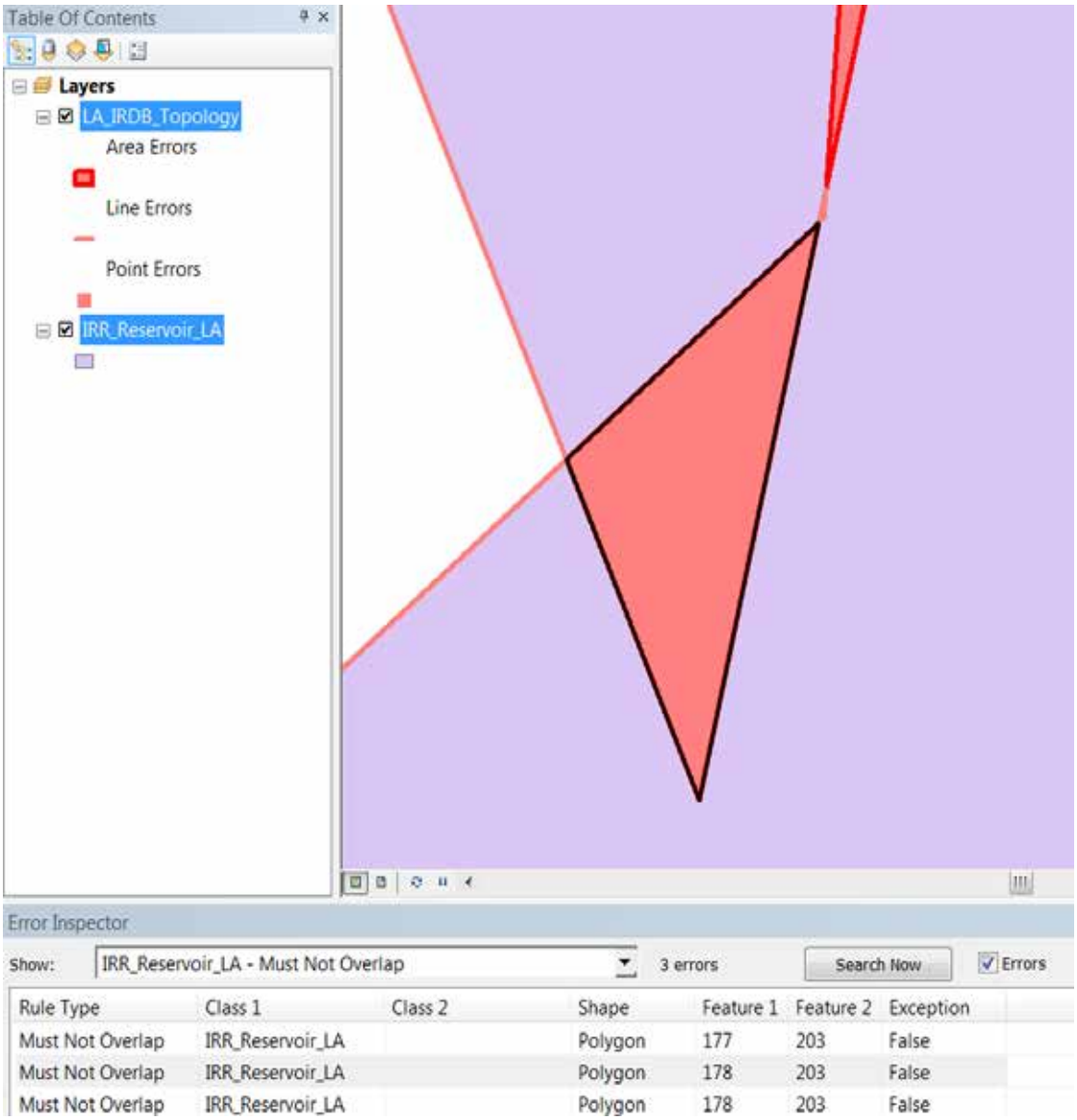


Figure 21: Overlap errors found in the Lao PDR irrigation reservoir dataset

PROJ_NAME	CC_CODE	AGENCY	NAME
Na dou	2	Lao	H lamtong
Done Mak kuea	2	Lao	H pabad
Non sa vag	2	Lao	H panieg
Nonglaothueng	2	Lao	H lao
Seset	2	Lao	Seset
Tavuey	2	Lao	H namsoum
Toldok	2	Lao	H men
Kokmuang	2	Lao	Hgalom
Houay Ka Dan Thong	2	LAO	Houay Ka DanThong
Houay Noy	2	LAO	Houay Noy
Hong Khen	2	LAO	Hong Khen
Houay Pha	2	LAO	Houay Pha
Nam Kong	2	INTER	Nam Kong
Houay Sup Kong	2	INTER	Houay Sob Kong
Houay Nam Pay	2	INTER	Houay Nam Pay
Houay Noy	2	INTER	Houay Noy
Houay Kou Li	2	INTER	Houay Kou Li
Huay Noy Ban Mai	2	INTER	Houay Ban Mai
Houay Nong Lub	2	LAO	Houay Nong Lub
Houay Hong Khen	2	LAO	Houay Hong Khen

PROJ_NAME	CC_CODE	AGENCY
Houyapyonghouane	2	Lao
Phaosampunmexai (Dakyeng)	2	Lao
Naxerk	2	Lao
B khung	2	Lao
Houysamong	2	Lao
Somelaung	2	Lao
Houykabong	2	Lao
Houykabong	2	Lao
Houykabong	2	Lao
Xepeng	2	Lao
Houykabong	2	Lao
Houymakchan	2	Lao
Vungtodnoy	2	Lao
yiengkak	2	Lao
Namngon	2	Lao
Nam Tin	2	Lao
H. Samock	2	Lao
H. Kaw	2	Lao
H. Kod	2	Lao
H. Sala 1	2	UNHCR

Figure 22: Spelling correctness of attribute values (attribute errors found Lao PDR datasets)

7.8 QA/QC Results for Thailand

The irrigation database from Thailand consists of 4 completed datasets. Those 4 datasets comprise 1) Irrigation Areas, 2) Irrigation Headworks, 3) Irrigation Projects, 4) Irrigation Reservoirs. From the first QA /QC result - they were separately processed by each Royal Irrigation Office (RIO). The detailed errors, either topology or attribute errors, are shown in ***Table 13*** and ***Figures 23 to 25.***

Table 13: Summary of errors found from the first QA/QC in the Thailand Datasets

Dataset	Rule Check	Topology Result	Recommendation	Attribute Check
Irrigation Areas	• Must Not Overlap • Must Not Have Gaps	• Found 1 overlapped feature	Need to fix the errors	• PROJ_NAME has inconsistent naming (…Res, … Reservoir, Reg, ..Regulator) • CC_CODE is inconsistent attribute (03, 3 and T) • AGENCY is inconsistent alphabet (Capital Letter) • EIA is short integer or floating number?
Irrigation Headworks	• Must Be Properly Inside	• Found 268 from 323 headwork locations are outside irrigation area	• *Headworks can be either on canals or on the ground, so just check the position of HW is inside irrigation area. This error may not need to be fixed but applied for checking concerns*	No errors found
Irrigation Projects	• Must Be Properly Inside	• Found 114 from 135 projects are outside irrigation area	• *This error may not need to be fixed but applied for checking concerns*	• PROJ_NAME has inconsistent naming (…Res, … Reservoir,…Reg, ..Regulator) • CC_CODE has inconsistent attribute (03, 3 and T) • AGENCY has consistent alphabet (Capital Letter) • SHEME_ID has no data in some records • APPL_MET has no data in some records • CN_YEAR has no data in some records (missing Or no data?)
Irrigation Reservoirs	• Must Not Overlap • Must Not Have Gaps	• Found 1 overlapped feature	Need to fix the errors	No errors found

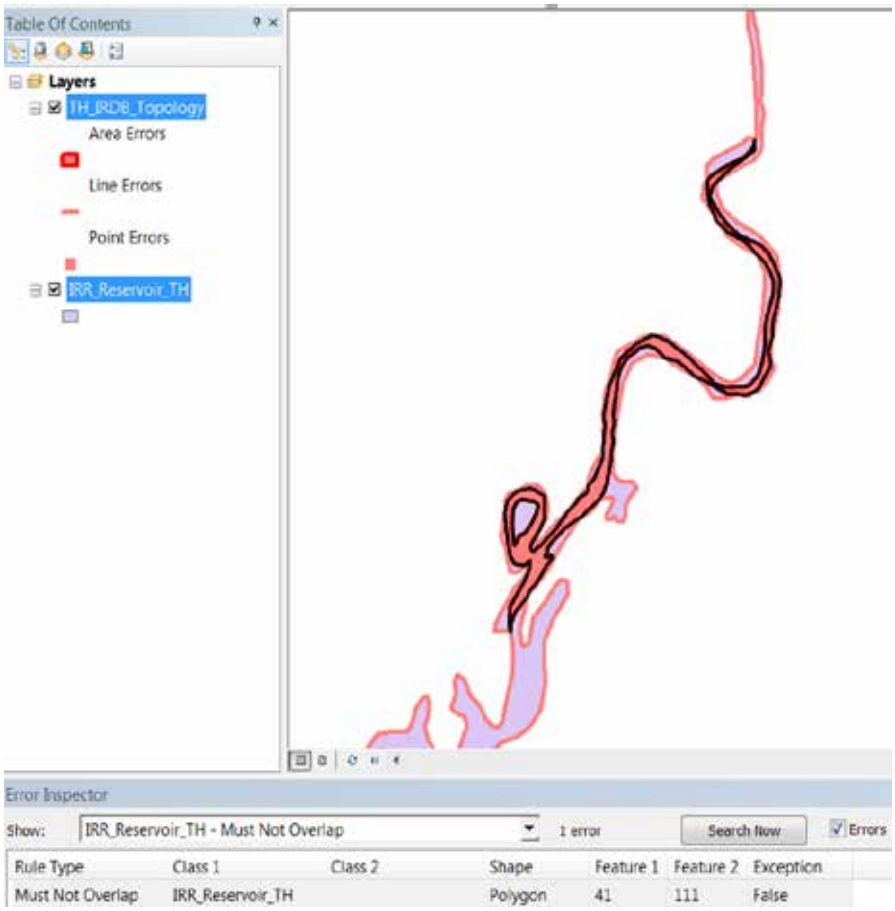


Figure 23: Overlap errors found in the Thailand reservoir dataset

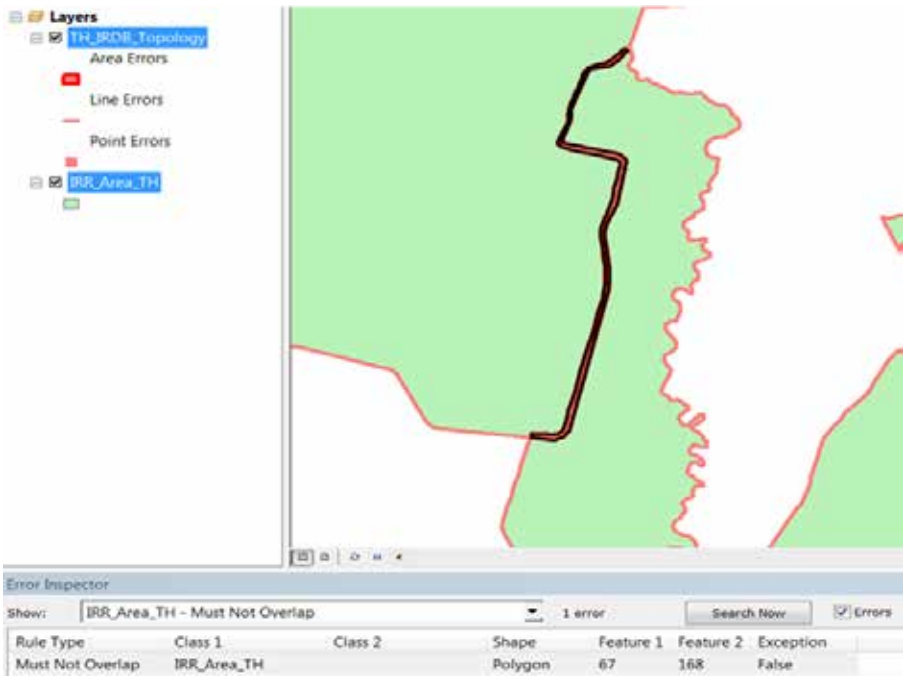


Figure 24: Overlap errors found in the Thailand irrigation area dataset

PROJ_NAME	CC_CODE	AGENCY	EIA_W
Sok Rang Res.	T	ROYAL IRRIGATION DEPARTMENT	16.016231
Huai Sai Res.	T	ROYAL IRRIGATION DEPARTMENT	334.766267
Nong Ta Kai Res.	T	ROYAL IRRIGATION DEPARTMENT	109.668768
Huai Nam Man (Lower) Weir.	T	ROYAL IRRIGATION DEPARTMENT	186.223287
Huai Nam Wak Res.	T	ROYAL IRRIGATION DEPARTMENT	90.875484
Huai Nam Suai Res.	T	ROYAL IRRIGATION DEPARTMENT	107.62319
Huai Nam Man (Upper) Res.	T	ROYAL IRRIGATION DEPARTMENT	238.664579
Huai Pong Huai Chom Huai Rai Res.	T	ROYAL IRRIGATION DEPARTMENT	92.181123
Huai Yang Res.	T	ROYAL IRRIGATION DEPARTMENT	530.798982
Huai Lin Khwai Res.	T	ROYAL IRRIGATION DEPARTMENT	1909.475975
Huai Heaw Res.	T	ROYAL IRRIGATION DEPARTMENT	140.002309
Huai E Lert Res.	T	ROYAL IRRIGATION DEPARTMENT	655.743182
Huai Nam Pao Res.	T	ROYAL IRRIGATION DEPARTMENT	198.799989
Huai Noi Res.	T	ROYAL IRRIGATION DEPARTMENT	112.25717
Nong Sam Rong Res.	T	ROYAL IRRIGATION DEPARTMENT	326.255116
Lum Khan Chu Reservoir Irrigation Project	03	Royal Irrigation Department	1533
Bung Lahan Reservoir Irrigation Project	03	Royal Irrigation Department	695
Ban Pet Reservoir Irrigation Project	03	Royal Irrigation Department	50
Lum Chor Ra-ka Reservoir Irrigation Project	03	Royal Irrigation Department	703
Huai Thong Lang Reservoir Irrigation Project	03	Royal Irrigation Department	325
Huai Som Poi Reservoir Irrigation Project	03	Royal Irrigation Department	3888
Huai Sai Reservoir Irrigation Project	03	Royal Irrigation Department	11690
Nam Phrom Irrigation Project	03	Royal Irrigation Department	7059
Kok Muang Reservoir Irrigation Project	03	Royal Irrigation Department	128

Figure 25: Spelling correctness of attribute values (attribute errors found in the Thailand irrigation area dataset)

7.9 QA/QC Results for Viet Nam

The irrigation database from Viet Nam consists of 4 datasets, namely: 1) Irrigation Areas 2) Irrigation Headworks 3) Irrigation Projects, and 4) Irrigation Reservoirs. There is 1 missing dataset - Irrigation Reservoirs in the Viet Nam Delta. From the first QA /QC result – found 6 overlapped area errors in the irrigation area dataset. From the attribute error check – found several errors regarding the spelling correctness of attribute values. The detailed errors, either topology or attribute errors, are shown in ***Table 14*** and ***Figures 26 to 27***.

Table 14: Summary of errors found from the first QA/QC in the Viet Nam Datasets

Dataset	Rule Check	Topology Result	Attribute Check
Irrigation Areas	• Must Not Overlap • Must Not Have Gaps	• Found 6 overlapped area errors	• PROJ_NAME has consistent alphabet (Capital Letter for the first one). And need to check the space from the spacebar press. • CC_CODE has inconsistent attribute (3, 03 and V) • AGENCY has consistent alphabet (Capital Letter) and Abbreviation (Need consistent for full name or Abbreviation) • EIA_W can be zero? • HW_ID is incomplete data

Irrigation Headworks	• Must Be Properly Inside	• Found 20 HW are outside irrigation area in the Delta • Found 1,307 HW are outside irrigation area in the Highlands	• CC_CODE is incomplete (Delta) • NAME_RIV is incomplete (441 features have missing names)
Irrigation Projects	• - Must Be Properly Inside	• *Found 1,309 project locations are outside irrigation area in the Highlands*	No errors found
Irrigation Reservoirs	• Must Not Overlap • Must Not Have Gaps	• Found 1 overlap error in the **Highlands**	No errors found

From the final QA /QC results there are still 6 overlapped area errors with 4 gap errors in the irrigation area dataset in the Highlands. While only 1 overlapped area error in the irrigation reservoir dataset was found in the Highlands that needs to be fixed or justified based on whether it is an initial error. The detailed errors from the final QA/QC are shown in ***Table 15*** and ***Figures 22 to 23***.

Table 15: Summary of errors found in the Viet Nam Datasets

Dataset	Complete Dataset	Rule Check	Topology Result	Recommendation	Attribute Check
Irrigation Areas	Yes	• Must Not Overlap	• Found 6 overlap errors in **Highlands**	Need to fix the errors	No errors found
		• Must Not Have Gaps	• Found 4 gap errors in **Highlands**	Need to fix the errors. It's the same area as the overlap errors.	
Irrigation Reservoirs	No reservoir in Mekong Delta	• Must Not Overlap	• Found 1 overlap error in **Highlands**	Need to fix an error or provide justification in this case for an exception	No errors found
		• Must Not Have Gaps	• No errors found	No errors found	
Irrigation Headworks	Yes	• Must Be Properly Inside	• *Found 20 HW are outside irrigation area in the **Delta***	*Headworks can be either on canals or on the ground, so just check the position of HW is inside irrigation area. This error may not need to be fixed but applied for checking concerns*	No errors found
			• *Found 1,307 HW are outside irrigation area in the **Highlands***	*This error may not need to be fixed but applied for checking concerns*	
Irrigation Projects	Yes	• Must Be Properly Inside	• *Found 1,309 project locations are outside irrigation area in the **Highlands***	*This error may not need to be fixed but applied for checking concerns*	No errors found

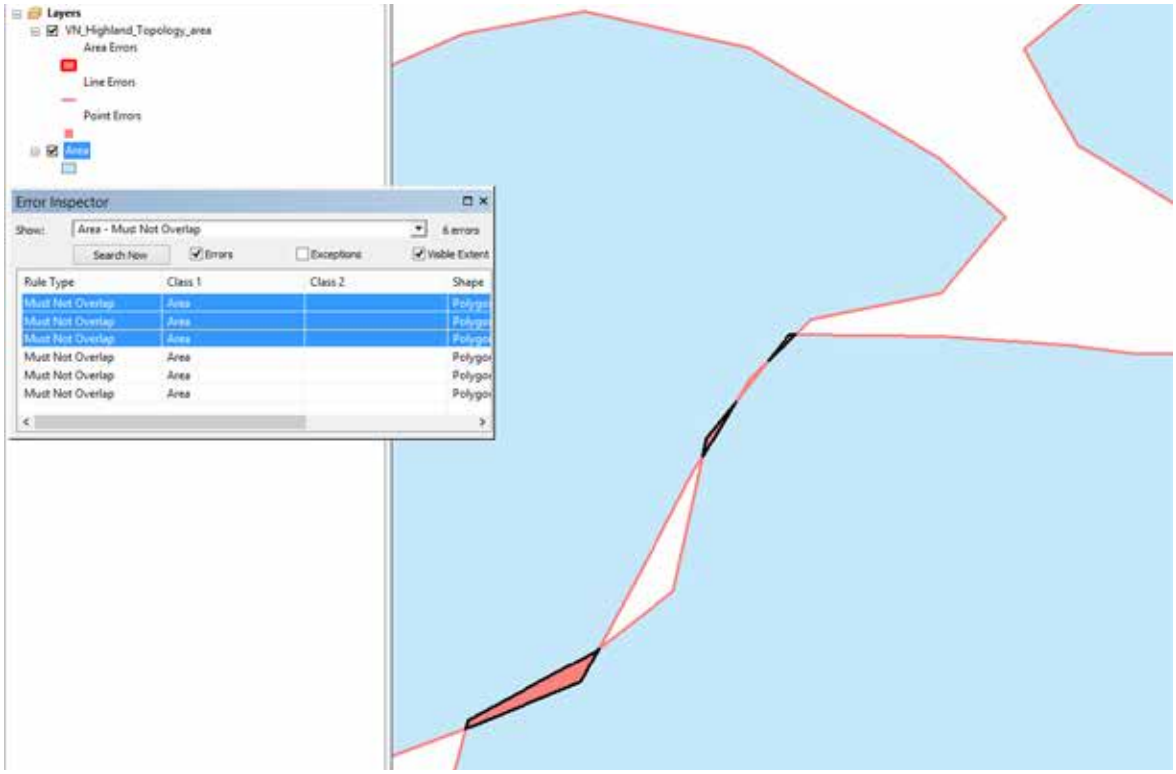


Figure 26: Overlap errors found in the Viet Nam irrigation reservoir dataset

PROJ_NAME	CC_CODE	AGENCY	EIA_W	AREA_ID	HW_ID	Shape_Length
North Mang Thit -	V	Dong Thap D	1526	V87700071A071		23660.54959
North Mang Thit -	V	Dong Thap D	3269	V87700072A072		39827.084569
Quan Lo Phung H	V	Bac Lieu Dep	2731	V95590034A034		46792.004495
Quan Lo Phung H	V	Ca Mau Depa	2091	V96640035A035		40098.213447
Quan Lo Phung H	V	Soc Trang D	34383	V94490029A029		89134.743865
Vai Co - 114	V	Long An Dep	29828	V91980114A114		142930.42725
Bac Lieu Vinh Ch	V	Bac Lieu Dep	629	V95600048A048		79198.130987
Tiep Nhat - 24	V	Soc Trang D	6626	V94450024A024		87858.447474
Plain of Reed - 10	V	Long An Dep	28825	V80990105A105		87850.60013
Plain of Reed - 10	V	Dong Thap D	48021	V87730104A104		125487.830477
Dak Ka Well	4	DARD	43.5	4626080097097	4626080097097	2601.13502
ong Tho	4	DARD	3.2	4626080103103	4626080103103	4462.432006
Dak Tia	4	DARD	120	4626080105105	4626080105105	8265.505954
Plei Ta Rop	4	DARD	9	4626080106106	4626080106106	5918.572816
Tan Dien	4	DARD	80	4626080109109	4626080109109	5166.064575
Toan Dan	4	DARD	0.4	4626080112112	4626080112112	3137.362006
Doi 18	4	DARD	17.1	4626080113113	4626080113113	3166.256809
Dak Sa Men	4	DARD	27	4626080114114	4626080114114	4486.292529
Po Ko	4	DARD	7	4626100268268	4626100268268	2463.927566
Dak Ho Nieng	4	DARD	266.51	4626110119119	4626110119119	4336.071694
Dak Long	4	DARD	124.95	4626110151151	4626110151151	7628.671574

Figure 27: Spelling correctness of attribute values (attribute errors found in the Viet Nam irrigation area dataset)

7.10 Database correction

In geodatabases, topology is the arrangement that defines how point, line, and polygon features share coincident geometry. Topology rules define the permissible spatial relationships between features. The rules you define for a topology control the relationships between features within a feature class, between features in different feature classes, or between subtypes of features.

Table 16: Polygon rule for area checks

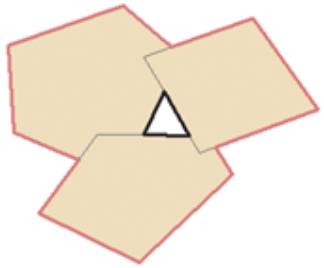
Topology rule	Rule description	Possible fixes	Examples
Must Not Overlap	This rule requires that the interior of polygons not overlap. The polygons can share edges or vertices. This rule is used when an area cannot belong to two or more polygons. It is useful for modeling administrative boundaries, such as ZIP Codes or voting districts, and mutually exclusive area classifications, such as land cover or landform type.	**Subtract:** The Subtract fix removes the overlapping portion of geometry from each feature that is causing the error and leaves a gap or void in its place. This fix can be applied to one or more selected Must Not Overlap errors. **Merge:** The Merge fix adds the portion of overlap from one feature and subtracts it from the others that are violating the rule. You need to pick the feature that receives the portion of overlap using the Merge dialog box. This fix can be applied to one Must Not Overlap error only. **Create Feature:** The Create Feature fix creates a new polygon feature out of the error shape and removes the portion of overlap from each of the features, causing the error to create a planar representation of the feature geometry. This fix can be applied to one or more selected Must Not Overlap errors.	
Must Not Have Gaps	This rule requires that there are no voids within a single polygon or between adjacent polygons. All polygons must form a continuous surface. An error will always exist on the perimeter of the surface. You can either ignore this error or mark it as an exception. Use this rule on data that must completely cover an area. For example, soil polygons cannot include gaps or form voids—they must cover an entire area.	**Create Feature:** The Create Feature fix creates new polygon features using a closed ring of the line error shapes that form a gap. This fix can be applied to one or more selected Must Not Have Gaps errors. If you select two errors and use the Create Feature fix, the result will be one polygon feature per ring. If you want one multipart feature as a result, you will need to select each new feature and click Merge from the Editor menu. Note that the ring that forms the outer bounds of your feature class will be in error. Using the Create Feature fix for this specific error can create overlapping polygons. Remember that you can mark this error as an exception.	

Table 17: Arc rule for line checks

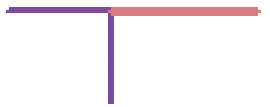
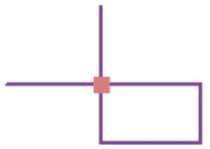
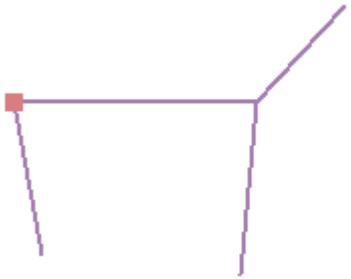
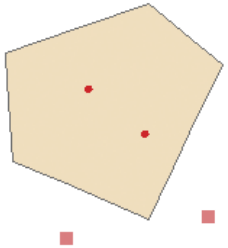
Topology rule	Rule description	Possible fixes	Examples
Must Not Self-Overlap	Requires that line features not overlap themselves. They can cross or touch themselves but must not have coincident segments. This rule is useful for features, such as streets, where segments might touch in a loop but where the same street should not follow the same course twice.	**Simplify:** The Simplify fix removes self-overlapping line segments from the feature in error. Note that applying the Simplify fix can result in multipart features. You can detect multipart features using the Must Be Single Part rule. This fix can be applied to one or more Must Not Self-Intersect errors.	 The individual line feature overlaps itself, with the error indicated by the coral line.
Must Not Self-Intersect	Requires that line features not cross or overlap themselves. This rule is useful for lines, such as contour lines, that cannot cross themselves.	**Simplify:** The Simplify fix removes self-overlapping line segments from the feature in error. Note that applying the Simplify fix can result in multipart features. You can detect multipart features using the Must Be Single Part rule. This fix can be applied to one or more Must Not Self-Intersect errors.	
Must Not Have Pseudo Nodes	Requires that a line connect to at least two other lines at each endpoint. Lines that connect to one other line (or to themselves) are said to have pseudo nodes. This rule is used where line features must form closed loops, such as when they define the boundaries of polygons or when line features logically must connect to two other line features at each end, as with segments in a stream network, with exceptions being marked for the originating ends of first-order streams.	**Merge to Largest:** it will merge the geometry of the shorter line into the geometry of the longest line. The attributes of the longest line feature will be retained. This fix can be applied to one or more Must Not Have Pseudo Nodes errors. **Merge:** The Merge fix adds the geometry of one-line feature into the other line feature causing the error. You must pick the line feature into which to merge. This fix can be applied to one selected Must Not Have Pseudo Nodes error.	
Must Be Single Part	Requires that lines have only one part. This rule is useful where line features, such as highways, may not have multiple parts.	**Explode:** The Explode fix creates single-part line features from each part of the multipart line feature that is in error. This fix can be applied to one or more Must Be Single Part errors.	 Multipart lines are created from a single sketch.

Table 18: Point rule for point checks

Topology rule	Rule description	Possible fixes	Examples
Must Be Properly Inside	Requires that points fall within area features. This is useful when the point features are related to polygons, such as wells and well pads or address points and parcels.	**Delete:** The Delete fix removes point features that are not properly within polygon features. Note that you can use the Edit tool and move the point inside the polygon feature if you do not want to delete it. This fix can be applied to one or more Must Be Properly Inside errors. **Remark: this error may not need to be fixed but applied for checking concerns.**	 The squares are errors where there are points that are not inside the polygon.

The topology validation was justified and rectified from the final QA/QC process based on the possible fixes methods as shown in the above tables. For example, the small data gaps were filled up and merged with an adjacent polygon that was likely to be the same area. The attribute errors were also rectified using technical knowledge, for example, making the same agency name to be consistent in terms of capital and small letters, and removing unreasonable spaces among the words or phrases. The key indexes, including Project ID, Headwork ID, Areas ID were checked in relationship for Lao PDR, Thailand, and Viet Nam, but they were newly generated for Cambodia. The new generation key indexes for Cambodia is based on the agreed data structure, the connection among project names and national ID provided by the national consultant, and possibility of location base. All errors were justified and rectified using techniques in GIS environment.

Table 19: Report on Quality Assurance of the irrigation database

1. Dataset	1.1 Dataset name	Irrigation Database (IRRI DB 2017)
	1.2 Dataset description	Latest updated IRRI DB for 4 datasets consist of irrigation area, reservoir, headwork, and project in 2017
	1.3 Data source	MRCS, NMCs and LAs
	1.4 Data type	Spatial database (polygon and point)
	1.5 PDIES group	Agriculture
	1.6 Topic category code	005
	1.7 ISO11915 group	mapDigital
	1.8 Access group	MRCS/LAs
	1.9 Access right	Read/Write
	1.10 File type	File Geodatabase
2. Metadata	2.1 Properly documented data	Software for documentation, using ISO 19115
3. Feature definition	3.1 MRC accepted terminology	Names and other terminologies are accepted by the MRC.
	3.2 MRC accepted classification systems	Classification system was created by the MRC.
	3.3 Classification completeness	Completed classification
	3.4 Classification applied **	n/a
	3.5 Remark on classification **	n/a
4. Geodetic datum and map projection	3.1 Consistency with existing spatial data presentations	UTM Zone 48 N, Datum WGS 1984
5. Topology	5.1 Consistency with existing spatial data presentations	Consistency with Google Earth at Scale 1:25,000
	5.2 Closed polygons	Topology correction was applied
	5.3 Unbroken networks	No network defined.
	5.4 Completeness of data records	Data was completed.
6. Positional accuracy	6.1 Identification of gross geo-referencing and/or coding errors	Positional accuracy is based on handheld GPS, and Google Earth. Name of geographic locations are based on the TOR.
	6.2 Consistency with existing spatial data presentations	Consistency with Google Earth and existing satellite image matches well by NMCs and LAs.
7. Attribute data	7.1 Accepted spelling	Original spelling defined by TOR. Therefore, spelling is accepted by the MRC.
	7.2 Accepted referencing and/or coding	Coding system was adapted from the TOR. MRC accepts this coding system.
	7.3 Consistency with official records	Consistency with official records obtained from the field survey form.
	7.4 Completeness	Attributes were completed.
	7.5 Accepted structure	Data file structure was applied according to TOR.
8. Additional info	8.1 Level of usefulness	Very useful for image processing classification. It is the basic required dataset.
	8.2 Location	TD\ IRRI DB\IRRI DB2017\
	8.3 Operator	Kritsana Kityuttachai
	8.4 QA Date	11/11/2017
	8.5 Remarks	MRC core database

Source: MRC Technical Note on Data Quality Assurance Manual for GIS 3Data Version 0.0

8. Metadata

Metadata is simply described as data about data. This is important in determining the source, scale, accuracy, and information related to datasets. All data held in the MRC-IS needs to be accompanied by a set of metadata. Metadata generally describe what the information in the dataset is, where it has come from and in what form it has been stored. This serves three main purposes. Firstly, it enables users of the data to check back when the data appears to indicate unusual results. Secondly, it is a means of recording changes made to the datasets as may happen from time to time, thus warning users that values have been adjusted. Thirdly, and importantly, the metadata provides an early indication to the experienced user of the reliability of the information. The responsibility for providing metadata lies with the Primary Custodian of the dataset, as described in the MRC Operational Data Delivery Procedures, and with the Data Custodian for data collected through MRC Programmes or Projects.

The ISO 19115 is based on a standard achieved through consensus. the ISO metadata standard better supports data sharing across national and cultural boundaries. The metadata templates provided in this document shall be applied to all datasets held by MRC, who has developed the metadata standard based on the ISO 19115. The main metadata components are shown in ***Table 21.***

Table 20: Main metadata of ISO 19115

Main Sections of ISO Metadata	
Metadata (MD_Metadata)	Root element that contains information about the metadata itself.
Spatial Representation Information (gmd:spatialRepresentationInfo)	Information about the geospatial representation of a resource.
Reference System Information (gmd:referenceSystemInfo)	Information about the spatial and temporal reference systems used in the resource.
Metadata Extension Information (gmd:metadataExtensionInfo)	Information about user specified extensions to the metadata standard used to describe the resource.
Identification Information (gmd:identificationInfo)	Information required to uniquely identify a resource or resources.
Content Information (gmd:contentInfo)	Information about the physical parameters and other attributes contained in a resource.
Distribution Information (gmd:distributionInfo)	Information about who makes a resource available and how to get it.
Data Quality Information (gmd:dataQualityInfo)	Information about the quality and lineage (including processing steps and sources) of a resource.
Portrayal Catalogue Information (gmd:portrayalCatalogueInfo)	Information identifying portrayal catalogues used for the resource.
Metadata Constraint Information (gmd:metadataConstraints)	Information about constraints on the use of the metadata and the resource it describes.
Application Schema Information (gmd:applicationSchemaInfo)	Information about the application schema used to build a dataset.
Metadata Maintenance Information (gmd:metadataMaintenanceInfo)	Information about maintenance of the metadata and the resource it describes.

Source: Workbook on ISO 19115 Geographic information – Metadata, NOAA 2012

Table 21: Metadata of the irrigation database 2017

Attribute	Description
Contact Address	Mekong River Commission Secretariat P.O. Box 6101, 184 Fa Ngoum Road, Unit 18, Ban Sithane Neua, Sikhottabong District, Vientiane 01000, Lao PDR Telephone: (856-21) 263 263. Facsimile: (856-21) 263 264 www.mrcmekong.org
Name	LMB Irrigation Database (IRRI DB 2017)
Area	Cambodia, Lao PDR, Thailand, Viet Nam, Lower Mekong Basin
Description	MRC regional dataset of an irrigation database improvement 2017 has 4 irrigation datasets; consist of irrigation area, reservoir, headwork, and project.
Source Map	Same as source datasets
Source Dataset	**Cambodia:** BDP DB 2009, MRCs DB 2001, AIFP DB 2004, and Irrigation project of council study. **Lao PDR:** AIFP DB 2004, BDP DB 2009, Lao topographic map 1: 100,000, Aerial photos 2011, Google Earth. **Thailand:** AIP DB 2004, BDP DB 2009, Thailand topographic map 1: 50,000, orthophoto 30 m., Google Earth, and field data collection. **Viet Nam:** AIFP DB 2004, BDP DB 2009, Vietnam topographic map 1: 50,000, Srepok topographic map 1: 50,000, Sesan topographic map 1: 50,000 and field data collection 2013, and Google Earth.
Source Agency	**Cambodia:** Mr. Sao Samphear National Consultant for Thematic Area of Cambodia Irrigation GIS Database under MRC Council Study **Lao PDR:** Department of Irrigation (DoI) **Thailand:** Royal Irrigation Department (RID) **Viet Nam:** Viet Nam-Highlands: Institute of Water Resources Planning (IWRP), and Viet Nam-Mekong Delta: Southern Institute for Water Resources Planning (SIWRP)
Generation	Description of dataset generation or reference to a **Technical Report on Irrigation Database Improvement of Lower Mekong Basin.**
Status	Completed with last update (11 11 2017)

Comments	The Mekong River Commission makes no warranties about this data and disclaims all responsibility and liability for all expenses, losses, damages, and costs which may be incurred as a result of the data being inaccurate or incomplete in any way and for any reasons. The data contained herein do not imply the expression of any opinion whatsoever on the part of the Mekong River Commission concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delineation of its frontiers or boundaries.
Documentation	Operator: Kritsana Kityuttachai
Georeferenced information	UTM Zone 48 N, Datum WGS 1984
Data format	File Geodatabase
Data type	Vector (polygon and point)
Attributes information	Description of attribute table reference to a **Technical Report on Irrigation Database Improvement of Lower Mekong Basin.**
Updates and changes	Changes to the database structure and updates attribute and primary key follow to the "Data field structure" for the project of Improving Irrigation Database (AIP Activity #1.4.1) agreed by the Member Countries on 10 – 12 September 2012 at Angkor Paradise Hotel in Siem Reap, Kingdom of Cambodia. Operator: Chamaporn Paiboonvorachat and Kritsana Kityuttachai

Source: MRC Technical Note on Data Quality Assurance Manual for GIS Data Version 0.0

9. Capacity Building Achievements

Through the project of irrigation database improvement (2012–2015), a number of technicians and expert groups advanced their knowledge on irrigation data and information, as well as their skills on GIS and spatial database building and management. The capacity building was provided through various channels, such as training workshops and on-the-job training in all Member Countries, except Cambodia, which contributed to updating the MRC irrigation database through the Council Study.

The trainings in the Member Countries can be categorized into two main subjects:

1) ArcGIS software for Irrigation Database Improvement

The training courses provided comprehensive knowledge and skills to the national technicians and staff involved in the project to understand technologies related to GIS, ArcGIS working environment, geodatabase building and management, mapping, irrigation database contents and structure, irrigation data and information.

2) QA/QC for geospatial database

The training courses provided comprehensive knowledge and skills to the national technicians and staff to understand basic principles on geospatial data QA/QC rules and processes, and applications for QA/QC of spatial data.

The training ensured that the national working groups can meet the objectives and requirements prescribed by MRCS and can provide good services to the project of the new MRC irrigation database improvement. During the period of project implementation, almost 200 participants, including members of working groups and line agencies had the chance to professionally and successfully learn and apply ArcGIS software to establish, manipulate, manage, and control and inspect the quality of irrigation geodatabases. The details of capacity building in the MCs are summarized in ***Table 24***.

Table 22: Capacity Building in the MCs for Irrigation Database Improvement

No.	Training topics	Date	Venue	Regional/ National
1	Regional GIS training on building and managing Irrigation database; Using ARCGIS 10.0	2-4 October 2012	MRCS-OSP in Phnom Penh, Cambodia	MRC
2	National training: GIS training on building and managing Irrigation database; Using ARCGIS 10.0 for Vietnam line agencies	23-25 January 2013	SIWRP in Ho Chi Minh City, Viet Nam	Viet Nam
3	National training on QA/QC for Vietnam line agencies	3-5 July 2013	MRC office in Ho Chi Minh City, Viet Nam	Viet Nam
4	National training: GIS training on building and managing Irrigation database; Using ARCGIS 10.0 for Laos' NWG and line agencies	21-26 December 2013	LNMC	Lao PDR
5	Training GIS ARCGIS version 10 - Meeting for consideration on applying available data for new database format of MRCs for Thailand line agencies	8-11 January 2014	Amphawa, Samut Songkhram, Thailand	Thailand
6	On-the-job training on ArcGIS for Irrigation Database Improvement for IWR	24-29 February 2014	Institute of Water Resources Planning, in Ho Chi Minh City, Viet Nam	Viet Nam
7	On–the-job training: GIS techniques for Irrigation Database Improvement for the Southern Institute for Water Resources Planning	17-21 March 2014	SIWRP in Ho Chi Minh City, Viet Nam	Viet Nam
8	National Training on QA/QC for improving the irrigation database by MRC for Thailand line agencies	21-22 October 2014	TNMC, Department of Water resources, Bangkok, Thailand	Thailand
9	On–the-job training: GIS techniques for Irrigation Database Improvement for NWG	27-28 December 2014	LNMC	Lao PDR
10	National training on QA/QC for Lao line agencies	5-6 February 2015	LNMC	Lao PDR
11	Training on QA/QC software developed by the working group to build codes for each project in MRCs format and workshops on updating and finalizing the new irrigation database	7-9 May 2015	Khao Yai, Nakhon Ratchasima, Thailand	Thailand

10. Workplan and Arrangements to Utilize and Maintain the Database, and Share Data with MRCS

10.1 Benefits of the new database for national and regional work

The new irrigation database was established, modified, and updated with higher accuracy of spatial position and more details of the quantitative parameters of the irrigation projects and schemes that will be useful for further analysis and planning. The new data structure provides linkages of each irrigation layer into one individual irrigation project that could be of benefit for querying and administration of the database. The quality of the database itself was also improved by the QA/QC process many times at both national and regional levels which could ensure the level of accuracy of the datasets and the conformity of data, such as directionality, connectivity, topology, and metadata adherence.

Moreover, the updated database can improve the capacity of data access under GIS environment and technologies. It provides new data services for strategic research and planning for irrigation development for each Member Countries at country level and is beneficial for Basin Development Planning and transboundary impact studies at regional level through strengthening cooperation in data sharing with the relevant agencies, especially the MRC and line agencies. One of the most significant benefits of the advanced field data in the new irrigation database is to support the calculation of the flow regime for hydraulic modelling, water balance, and other hydrology research and projects. It is also one of the most complete regional databases that can be used to serve studies on the planning and development of water resources and irrigation schemes within the Lower Mekong Basin

10.2 Workplan and arrangements to utilize the database

At national level, the Member Countries submitted national irrigation databases to MRCS for the main purposes of publication, use and utilization among the MCs. The irrigation database will be beneficial as databases and information in research, ongoing and upcoming development projects, and national planning policies. After using the database, users will provide feedback and suggestions to database managers to improve the accuracy of the data records. There is no plan for the MCs to utilize the database in specific projects. Only the Institute of Water Resources Planning (IWRP) of Vietnam has stated that it will apply the results of this activity for the Master Plan of Water Resources in the Central Highlands and the Plan of Water Resources to restructure the agricultural sector in the Central Highlands. IWRP will also share the activity results with the Ministry of Agriculture and Rural Development (MARD) and the provinces in the study areas to serve local development.

At regional level, the MRC irrigation database will be maintained in the MRCS information and database management system managed by the Technical Support Division (TD) of MRCS. Data dissemination will be operationalized through the MRCS Web Portal following the Procedures for Data and Information Exchange and Sharing (PDIES) for data and information exchange among MRC Member Countries and made available for public access as determined by the National Mekong Committees (NMCs). The MRC irrigation database will also be used within MRCS to develop a comprehensive knowledge base on parameters fundamental to Integrated Water Resources Management, interdisciplinary studies, and water management for agriculture, the irrigation sector, and other related sectors. Besides, the database will be

used as fundamental data and information to prepare the State of Basin Report, the guidance for the design and operation of irrigation systems with transboundary implications, and the Basin Development Plan and Strategy, etc.

10.3 Workplan and arrangements to regularly update the database and share data with MRCS

The update of the irrigation database will be variable depending on the development of irrigation infrastructure in each country within the basin. The Member Countries agreed on the importance of regularly updating the irrigation database to maintain its quality for the national and regional irrigation status and database; however, it is difficult to regularly update the irrigation database because such activities are outside their work routine and involve many agencies. The current MRC irrigation database was updated based on the existing data. If regular updates are required, more funding for data collection and permanent staff are required to update the data. The updating of national irrigation databases is suggested depending on each Member Country's decision. ***For the regional irrigation database, it is recommended to be updated every five years.*** However, before starting implementation, MRCS must identify the needs of MRC database utilization and the needs for the updating the new database and consult with the Member Countries in advance.

11. Conclusions and Recommendations

11.1 Conclusions

The irrigation database is one of the sector data assigned by the MRC's Member Countries that needs to be regularly maintained and updated according to the Procedures for Data and Information Exchange and Sharing (PDIES). Through the implementation of the MRC activity on improving the irrigation database in the Lower Mekong Basin, the Member Countries gathered data and information in both spatial and non-spatial formats, for gap-filling, revising, and updating the old MRC irrigation databases of 2004 and 2009. This new irrigation database is aimed at overcoming the disadvantages and shortcomings of the old database and providing a comprehensive, reliable, and connected data structure among five irrigation schemes/ layers, including irrigation projects (as a primary layer), existing irrigation headworks, existing irrigation areas, existing irrigation reservoirs, and existing irrigation canals (optional). This database is not only important as primary data for MRC's institutions and relevant line agencies in the government sector, which use this database for basin and sub-basin development plans, policies, and strategies, but also to other local authorities, education and research institutes for further study of water resources management. Furthermore, during the implementation of the project, capacity building in the form of in-house workshops and on-the-job training was provided to the National Working Groups. Through the training programs, all implementing personnel can access GIS-based technology and approaches in irrigation data collection and processing, including applying ArcGIS software to establish irrigation database and tools for QA/QC processes to control and ensure the quality of the database. Under the consultation and agreement of the Member Countries, the new irrigation database and related information will be uploaded to the MRCS information system and made available on the MRC web portal for further exploitation.

11.2 Recommendations

Without collaboration among the MRC Member Countries, the regional irrigation database improvement could not have succeeded. As experiences gained from the activity implementation, some areas for improvement remain for project implementation in the future. The recommendations can be summarized into four groups as below:

- **Improvement of the accuracy of the database:** The irrigation information has been regularly changed due to new works and constructions of irrigation schemes or new operations and maintenance by local governments. Therefore, to ensure the accuracy of the database, additional investigation is required to ascertain exact locations and details of irrigation works; for example, size and parameter of irrigation works, investment and operation of the irrigation facilities. The database should be maintained and updated regularly or when new projects have been started. The extra time and funding for field data collection are needed for the future project on improvement of the irrigation database.

- **Data quality:** If the future improvement of the irrigation database in some countries could have the participation of provincial offices, it will save time and effort, increase the effectiveness of data collection, and improve the quality of the database. Moreover, the technical guidelines for database improvement should be prepared beforehand for standardization and consistency of processes and methods in generating the results. Furthermore, all Member Countries should be involved in the same activities and platform of database improvement to make the database more consistent.

- **Regular update of the irrigation database:** The irrigation database is an important source for planning and development in various sectors related to water-use, such as agriculture, fisheries, hydropower, navigation, etc.; therefore, the regular update of the irrigation data and information is needed. The Member Countries suggested that MRC should prioritize the updating and improving of the irrigation database. The expansion of scope should be considered to include the irrigation databases of China and Myanmar to create the entire Mekong Basin database. Guidance on updating the irrigation database is needed for continuous maintenance even though the persons in charge may change.

- **Data dissemination:** The irrigation database should be disseminated and made usable for users at all levels. As aforementioned, authorized MRC data dissemination needs to follow the Procedures for Data and Information Exchange and Sharing (PDIES) for data and information exchange among MRC Member Countries and made available for public access as determined by the National Mekong Committees (NMCs).

- **Capacity building:** Training courses on irrigation database improvement should be organized for staff of national line agencies and local staff of the Member Countries with support of MRCS. In addition, staff who participated and benefited from this project should transfer their knowledge to junior staff and organize capacity building for their own staff on a regular basis, either with on-the-job training or workshops, in their own organizations.

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ANNEX

ANNEX 1: Data structure of the 2017 MRC Irrigation Database

The Irrigation Database is designed as a spatial database. Every record (i.e. irrigation project/system) must have a single point data (Irrigation Project). Every record must also have all the major[4] point (Headworks) and polygon (Irrigation area and Irrigation reservoir) data if the project/ system exists and has these components. The same record may also contain multiple polylines (Irrigation canals). If the record is still under planning, only the single point will be contained in the Database. The following tables describe the contents of attribute tables of each of the aforementioned "shape data unit" of the 2017 MRC Irrigation Database.

Remark: The spatial database is made of layers that contain point, polygon, or polyline shapes. The individual point, polyline, or polygon is composed of vector data and an attribute table. The following tables describe the data fields of the attribute table of each point, polygon or polyline data.

Note:

Code Name: Name of data fields. Contents to be stored in the corresponding data field are specified in "Definition."

Classification: Whether submission of the corresponding data is obliged or optional. The scope or expanse of obligatory collection of the "Mandate" data field in the "Option", as explained in the below point. The "Mandate" for data collection means the MCs need to provide these data and information to improve the national irrigation database. On the other hand, "Optional" means the MCs can consider providing or not provide those data and information based on their availability and accessibility.

Condition: The scope of the data collection. The following three cases are given:

- **MA**: All nationally planned irrigation projects and the existing irrigation systems that the national government recognizes as necessary infrastructure to maintain the national irrigation area.
- **MN**: All the available records on national inventories (including those maintained by regional, project or branch offices).
- **MF**: The data field with this sign must be filled when the corresponding data is recorded.

4 Pease refer to Condition MN for "major" items.

Data type: Whether the contents are numerical (if they are meaningful to be added up: number) or not (text).

Field size: Space allocated for the data field of the database structure in digits or the number of characters.

Definition: Specific description of the contents to be stored in the corresponding data field.

Unit: Unit for recording numerical data.

Selection: Available (single or multiple) choices for the data field.

Explanatory note: Supplemental information on Definition, Unit, and Selection.

Irrigation Project (point)

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJ ID	Mandate	MA	Text	20 P	Unique index for all the dataset to be assigned by MRC	-	-	+country code(2digits)IKMP +province code(2digits)IKMP +district code(2digits)IKMP + project code(4) P
PROJ NAME	Mandate	MA	Text	50	Project name	-	-	Type "TEMP+PROJ ID" if the project name is not identified
CC CODE	Mandate	MA	Text	2	Country Code	-	C/L/T/V	
PRONAME	Mandate	MA	Text	20	Provincial Name			
PROVCODE	Mandate	MA	Text	2	Province code			IKMP will support initial data layer
DISTNAME	Mandate	MA	Text	50	District Name			District where the chosen X/Y UTM of Irrigation Project exists
DISTCODE	Mandate	MA	Text	4 P	District Code			IKMP will support initial data layer P

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJCODE	Mandate	MA	Text	4 P	Project Code			Serial index number given to each project within the district
SCHEME ID	Option		Text	50	ID for a group of projects falling under one larger scheme	-	-	Based on each country's coding system Suggested code structure CC code (2digits) +Provcode(2)+Distcode(2)+Project name+code(3)
BDP PRJ ID	Option		Text	20	Proj ID used in the BDP2009 Irrigation Database			To be checked by the PROJ NAME and X/Y UTM
AGENCY	Mandate	MA	Text	60	Name of responsible agency	-	-	Type "TBD" if the agency is not clear
IRRI TYPE	Mandate	MA	Text	2	Irrigation system type	-	G-Gravity; P-Fixed pump; E-Fixed Electric Pump; D-Fixed Diesel Pump; F-Flood retention; L-Tidal Irrigation	Type of diversion and conveyance systems Type "TBD" if the type is not classified
APPL MET	Option		Text	2	Typical field application method	-	G-Gravity, M-Mobile or portable pumps; T-Traditional lift; O-sprinkler, drip tube, etc.	

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
STATUS	Mandate	MA	Text	2	Status of the project	-	E – Existing; P – Planned	The planned projects are planned for implementation in national socio-economic and sector plans. They shall be studied and have sufficient information on the project characteristics (at least preliminary feasibility study or feasibility study)
FUNDING	Option		Text	20	Status of planning and funding	-		
CN YEAR	Option		Number	4	Year of construction completion	A.D.		
POINT LOC	Mandate	MA	Text	3	Representative point	-	H-Headwork location (preferred) C-Centre of irrigation area L-Approximate scheme location D-District Office location	Type "TBD" if the UTM is available and yet reference point is not clear. Record XY-UTM of the district office and choose "D" if UTM is not available
X UTM	Mandate	MA	Number	10,6P	Longitude (WGS1984)	DD P	-	Decimal degree UTM Zone 48N
Y UTM	Mandate	MA	Number	10,6P	Latitude (WGS1984)	DD P	-	Decimal degree UTM Zone 48N
ACT IRRI W	Mandate	MN and If STATUS=E	Number	10	Actual irrigable area in the wet season either by the method 1 or 2 in the explanatory note.	ha	-	1. The area that would receive the sufficient amount of water to fulfill the crop water requirement calculated based on the general planning practice in the country. 2. The area that receives sufficient water during the specified irrigation season in four out of every five years in perception.

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
MAX RICE W	Mandate	MN and If STATUS=P	Number	10	Estimated maximum wet season irrigable area for rice crop for planned irrigation project	ha	-	
AREA BASE	Mandate	MN	Text	2	Method for the determination of irrigable area	-	1-Plan, 2-Observation	Pls see the explanatory note of ACT IRRI W
STAR DAY	Option		Text	4	Starting day of the wet season irrigation service	ddmm		
END DAY	Option		Text	4	Final day of the wet season irrigation	ddmm		
ACT IRRI D	Option		Number	10	Actual dry season irrigable area	ha	-	The area normally irrigated in the dry season
MAX IRRI D	Option		Number	10	Estimated maximum dry season irrigable area for rice crop	ha	-	For planned or potential irrigation projects
ACT IRRI 3	Option		Number	10	Actual 3rd season irrigable area	ha	-	The area normally irrigated in the 3rd season
MAX IRRI 3	Option		Number	10	Estimated maximum 3rd season irrigable area for rice crop	ha	-	For planned or potential irrigation projects
CROP COD	Option		Text	2	Crop code	-	1-one rice crop per year, 2-two rice crops per year 3-three rice crops per year M-mixture of rice and other crops	
SOIL L	Option		Text	50	Soil legend	-		Based on FAO/UNESCO 1988 classification system

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
DC YEAR	Mandate	MA	Number	4	Year of data collection	A.D.	-	
PROJ FUNC	Mandate	MN	Text	20	Project functions		WS-Water Storage, DR-Drainage, SR-Soil reclamation/ Acid Sulfate Control, WC-water conservation, FC-Flood control, HP-Hydropower, DW-Domestic Water supply, AF-Aquaculture (Freshwater), AB-Aquaculture (Brackish water), SL-Salinity control	Multiple Choice
PRO COST	Option		Number	10	Project cost	US$M	-	US$1=R4000/K8000/B30/D20000
N DAM	Mandate	MN	Number	3	# of reservoirs		-	“Reservoirs” do not include regulation ponds or farm ponds
N DIV	Mandate	MN	Number	4	# of diversion dams/head works		-	
MCANAL L	Option		Number	10	Km of main canals	km	-	
SCANAL L	Option		Number	10	Km of secondary canals/ laterals	km	-	
N PUMP	Option		Number	4	# of pump stations		-	
DIKE L	Option		Number	10	Km of levees/dikes	km	-	
DRAIN L	Option		Number	10	Km of drainage channels	km	-	
N IRRI F	Option		Number	10	# of irrigated farm households		-	

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
FARM ROL	Option		Text	2	Farmers' role in Operations Management & Maintenance	-	1-Financially autonomous and responsible for whole system management 2-Part of system operations and maintenance 3-Field application only	
CONJ USE	Option		Text	2	Use of groundwater as the source	-	1-Major source, 2-Minor source, 3-No use	

Existing Irrigation Headworks (Point)

This point data must be recorded if the corresponding data is available in the national inventories (including those maintained by regional, project or branch offices).

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJ ID	Mandate	MN, MF	Text	10 P	Unique index for all the dataset to be assigned by MRC	-	-	country code(2digits)+province code(2digits)+district code(2digits)+ project code(4digits) P
PROJ NAME	Mandate	MN,MF	Text	50	Project name	-	-	
CC CODE	Mandate	MN, MF	Text	2	Country Code	-	C/L/T/V	
AGENCY	Mandate	MN, MF	Text	50	Name of responsible agency	-	-	Type “TBD” if the agency is not clear.
HW ID	Mandate	MN, MF	Text	14 P	Headworks ID	-	-	PROJ ID plus “H” plus the 3-digit headwork code recognized by the riparian country
X UTMHW	Mandate	MN, MF	Number	10,6 P	Longitude of the headworks location(WGS1984)	DD P	-	Decimal degree (UTM Zone 48N)
Y UTMHW	Mandate	MN, MF	Number	10,6 P	Latitude of the headworks location(WGS1984)	DD P	-	Decimal degree (UTM Zone 48N)
HW TYPE	Mandate	MN	Text	20	Headworks type	-	P-Pump station, R-Reservoir, W-Weir, B-Barrage, D-Division gate/regulator, O-Others	
NAME RIV	Mandate	MN	Text	50	Name of intake river	-		
AREA ID	Mandate	MN,MF	Text	14 P	Irrigation Area ID	-	-	The one corresponding to the major benefit area of the headwork
MAX DV	Option		Number	10	Maximum diversion volume	M3/s		
FISH PATH	Option		Text	2	Availability of fish passage	-	1-Year-round path with a minimum flow, 2-regulated part-time path, 3-no structure for fish passage	

Existing Irrigation Area (Polygon)

This polygon data must be recorded if the corresponding data is available in the national inventories (including those maintained by regional, project or branch offices).

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJ ID	Mandate	MN, MF	Text	10 P	Unique index for all the dataset to be assigned by MRC	-	-	country code(2digits)+province code(2digits)+district code(2digits)+ project code(4digits) P
PROJ NAME	Mandate	MN, MF	Text	50	Project name	-	-	
CC CODE	Mandate	MN, MF	Text	2	Country Code	-	C/L/T/V	
AGENCY	Mandate	MN, MF	Text	50	Name of responsible agency	-	-	
EIA W	Mandate	MN	Number	10	Existing Irrigated Area in Wet seasons	ha	-	Value calculated from the polygon
AREA ID	Mandate	MN,MF	Text	14 P	Irrigation Area ID	-	-	PROJ ID plus “A” plus the 3-digit area code recognized by the riparian country
HW ID	Mandate	MN, MF	Text	14 P	Headworks ID	-	-	The one corresponding to the major source for the area

Existing Irrigation Reservoir (Polygon)

This polygon data must be recorded if the corresponding data is available in the national inventories (including those maintained by regional, project or branch offices).

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJ ID	Mandate	MN, MF	Text	10 P	Unique index for the dataset to be assigned by MRC	-	-	country code(2digits)+province code(2digits)+district code(2digits)+ project code(4digits) P
PROJ NAME	Mandate	MN, MF	Text	50	Project name	-	-	
CC CODE	Mandate	MN, MF	Text	2	Country Code	-	C/L/T/V	
AGENCY	Mandate	MN, MF	Text	50	Name of responsible agency	-	-	
NAME DM	Mandate	MN, MF	Text	50	Name of dam/reservoir	-		
DAM STRU	Mandate	MN	Text	5	Structural type	-	ED-Earth dam ZF-Rockfill or Zoned Fill dam CN-Concrete dam CM-Composite dam	
R PURPOSE	Mandate	MN	Text	6	Purpose of reservoir	-	F-Flood control H-Hydroelectricity D-Domestic water supply	Additional purpose of the reservoir Multiple Choice
TOT CAP	Mandate	MN	Number	10	Active total capacity	1000m3		Type 15 if the capacity is 15,000 m3
CAP IRRI	Mandate	MN	Number	10	Active capacity for irrigation	1000m3		Type 15 if the capacity is 15,000 m3

Existing Irrigation Canal (Polyline)

Code Name	Classification	Condition	Data type	Field size	Definition	Unit	Selection	Explanatory note
PROJ ID	Option	MF	Text	10 P	Unique index for all the dataset to be assigned by MRC	-	-	country code(2digits)+province code(2digits)+district code(2digits)+project code(4) P
PROJ NAME	Option	MF	Text	50	Project name	-	-	
CC CODE	Option	MF	Text	2	Country Code	-	C/L/T/V	
AGENCY	Option	MF	Text	50	Name of responsible agency	-	-	
C LENGTH	Option		Number	8	Length	km		Value calculated from the polyline
CANAL CLS	Option		Text	4	Canal Classification	-	M-Main Canal S-Secondary Canal U-Unclassified	
CANAL TYPE	Option		Text	6	Structural type	-	E-Earth canal L-Lined canal F-Flume P-Pipeline	
CANAL CON	Option		Text	6	Conditions	-	F-Fully functional P-Partially damaged N-Non-functional	

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