HO CHI MINH CITY

FLOOD RISK MANAGEMENT SYSTEM (FRMIS)

CONCEPT AND PROPOSED ROAD MAP FOR FRMIS ESTABLISHMENT

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Abbreviations and Acronyms

CPC	People Committee of the city
DARD	Department of Agriculture and Rural Development
DOC	Department of Construction
DONRE	Department of Natural Resources and Environment
DOT	Department of Transport
DPI	Department of Planning and Investment
DST	Decision Support Tool
FRM	Flood Risk Management
FRMIS	Flood Risk Management Information System
IFM	Integrated Flood Management
IMC	Infrastructural Management Center
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
O&M	Operation and Maintenance
SDI	Spatial Data Infrastructure
SPP	Spatial Planning Platform
UDC	Urban Drainage Company
UICI	Urban Infrastructural Construction Investment
WCP	Water Control Plan

CHAPTER 1 - INTRODUCTION

HCMC has approved a flood prevention program in January 2020. The current flood management approach is fragmented and lack consideration of critical factors like tidal flooding and climate change. Existing infrastructure is insufficient and lack synchronization. Existing data and planning method is also inadequate for comprehensive risk integration. Overall education is needed to raise public awareness on FRM and related environmental issues. HCMC seeks WBG support in the 2 following areas: (i) **FRM planning and reform:** Assess existing HCMC flood risk management (FRM) plans; prepare an institutional assessment to address fragmentation of roles and responsibilities and a roadmap for institutional reform in FRM; identify existing data, information, models and tools used by different city departments and external institutes and prepare a roadmap to connect this information into an integrated Flood Risk Management Information System (FRMIS); identify methods to apply information and technology in the management and operation of the drainage and other systems and (ii) **Infrastructure solutions:** Study solutions, along with the financing options, to (i) prevent flooding caused by rain and control tides for Thu Duc city area (region III) and (ii) complete the tidal control for Zone I (the entire area on the right bank of the Saigon - Nha Be river); provide financial support for investments in new infrastructure.

This paper presents a (draft) Concept Note and Road map for development of a FRMIS for the city. This draft has been prepared by the joint team on FRM of WBG and HCMC that will be discussed and agreed by both WB and HCMC Authorities on main following issues:

- The Need of FRMIS development and deployment for HCMC as a support tool for Integrated Urban Flood Risk Management;
- Conceptual Design of the FRMIS and
- Road map for FRMIS development and deployment for HCMC including Flood Management reform requirements.

CHAPTER 2 – FLOODING AND FLOOD RISK MANAGEMENT IN HCMC

HCMC is the second largest city of Vietnam, consisting of 19 urban districts and five rural districts with a total area of 2,096km2. HCMC is also the leading economic centre of the country. The city is located in the lower reaches of the Sai Gon-Dong Nai (SG-DN) river catchment, a low-lying flood-prone delta, with some 64% of the area located below +1.5 m above mean sea level. Frequent flooding hampers the fast urban and economic development of the city which functions as a key growth center in the southern part of the Vietnam. Frequent surface water flooding due to intense rainfall events; however, several key factors contribute to or exacerbate the surface water flooding events in the city, including low ground elevation, high tides increase the water level in main rivers and canals, high water levels in rivers due to flows from upstream (natural or from reservoir discharges). Uncertainties of climate change impacts further threaten to increase the flood hazards. Sea level rise will also increase the risk of tidal flooding, riverine flooding and surface water flooding due to the interactions between these systems. Urbanization and population growth are likely to increase flood risk through impacts including encroachment on canals, green spaces and floodplains that act as water retention spaces, increases in rate and volume of runoff, urban heat island effects on rainfall, subsidence due to increased groundwater abstraction.

Figure 1. Rainfall flooding in Thuduc city, 2021

Figure 2. Tidal flooding in Hochiminh city, 2021

Flood risk in HCMC is exacerbated by insufficient drainage network capacity. Despite annual maintenance and upgrades, the authorities have not yet been able to adapt the drainage system in line with the rapid development and urbanization of the city. The drainage system is always overloaded, leading to surface water flooding during and after rainfall events. HCMC faces issues concerning drainage network data management which hinder authorities' ability to manage and prioritize drainage network improvements. HCMC's drainage network has been established during multiple timeframes and managed by various city agencies such as DOC and districts and privates over the years. This has led to data quality issues and significant gaps in existing drainage network data coverage, and there are several partial datasets and databases held by different city stakeholders. The lack of a single, centralized database of drainage network data means that city authorities do not have a full view of available data or standardized procedures to ensure the quality of data, limiting understanding of the drainage network and the ability to optimize network performance through targeted improvements.

Over time various measures have been taken to remediate the impact of flooding on daily live. Existing flood management infrastructure includes dykes, drainage canals, pumping stations, flood gates, etc. Significant Vietnamese and ODA funds have been allocated from the 1990ties till present for a number of projects which aim at identifying and implementing (partial) solutions for flood protection. Main implementation projects are: The drainage improvement project, based on the JICA-supported master plan for drainage of HCMC, which was approved in 2001; Implementation of the construction works is ongoing and will last till 2020.

The Water Work Control Plan for Flood and Inundation Management in HCMC (the so-called MARD Plan, approved in 2008) then a variant MARD plan has been selected and six big gates and pumps in the south of city for tidal water level control purpose have been installed by city fund. However, most of these projects focus on a part of the flood problems without applying an integral approach.

Hochiminh city now also is required to develop a vision on how to deal with new uncertainties in flood management, like the impact of climatic change, planned and unplanned urban development, etc. This may lead to a choice for more flexibility and a stepwise approach in flood protection. Next to Protection also Adaptation and Mitigation need to be considered in the strategy development. Therefor the Hochiminh city has specifically choose for the Integrated Flood Management Approach, which considers adaptive measures such as spatial planning, floodproof infrastructure, retention areas… as essential components. Hochiminh city also needs smart tools for urban flood risk management including Flood Risk Management Information system and Spatial Planning support Platform.

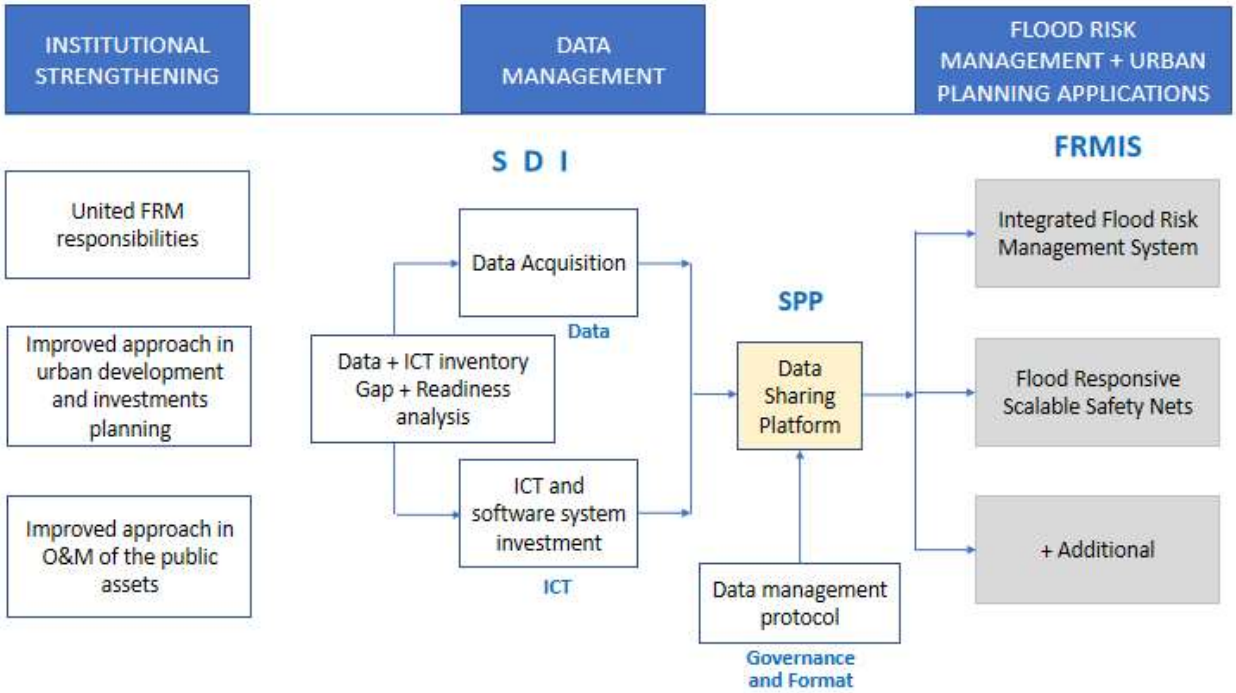


Figure 3. Concept for Integrated Planning Framework

CHAPTER 3 – FRMIS CONCEPT

Integrated flood risk management (IFRM) comprises all activities to cope with flooding hazards, ranging from construction and operation of infrastructure to flood proof urban planning. To faciliate the IFRM, one of the most important management tools is the Flood Risk Management Information System (FRMIS), which enables the relevant department and stakeholders to make appropriate decision in both emergency response and investment and urban planning. The FRMIS consists of the whole information chain (input, processing and output). In principle, the FRMIS has two essential functions: *(i) daily operation, including emergency response/early warning operation of the city's flood prevention infrastructures (online); and (ii) flood risk scenarios analytical advisory services to planning and investment decision processes (offline).* Depending on the needs of the cities at any time, the FRMIS can be extended in both its geographical coverage and functions, such as water transport, water sanitation environmental management, disaster insurance, etc. The FRMIS tool itself is very simple in term of the design and deployment. But the operation

of the FRMIS requires a more systematic collaboration among the relevant departments and stakeholders in the city. The conceptual design of the FRMIS can be found in figure 4 and 5 below.

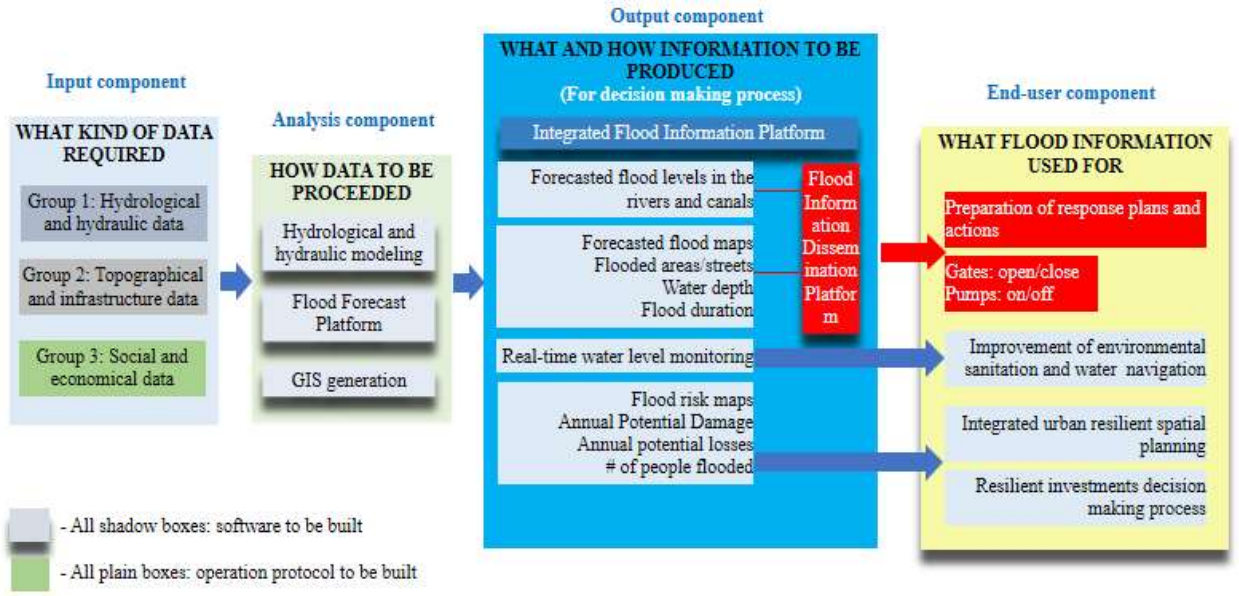
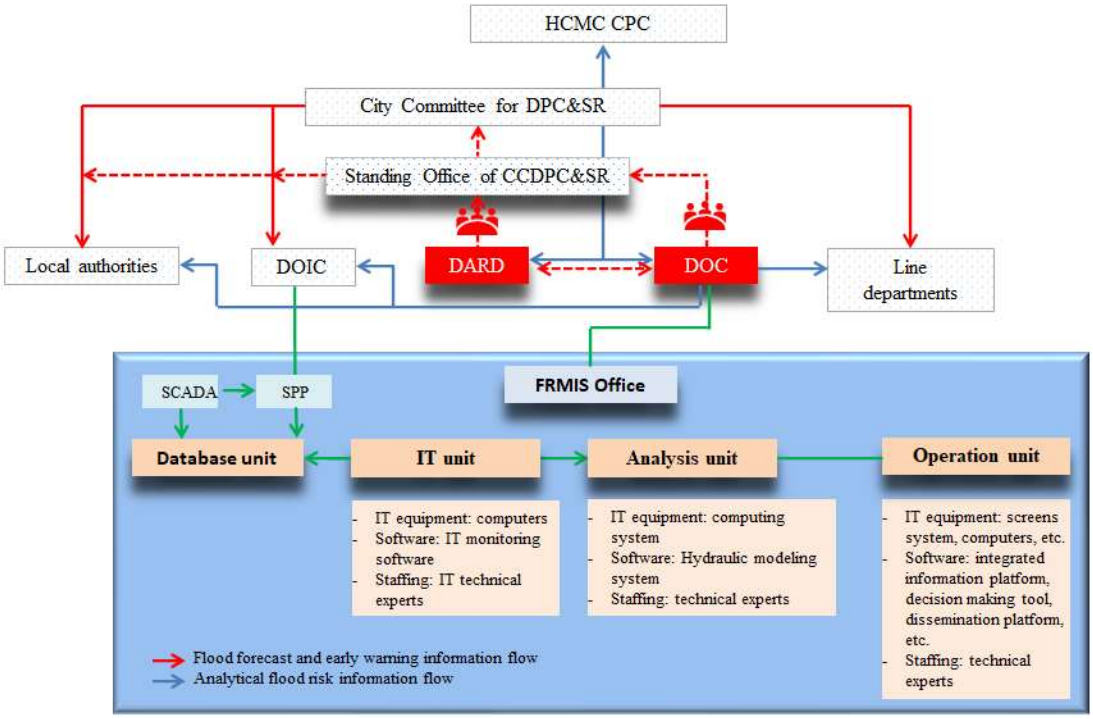


Figure 4. Conceptual design of the ICT tool of the Flood Risk Management Information System (FRMIS)



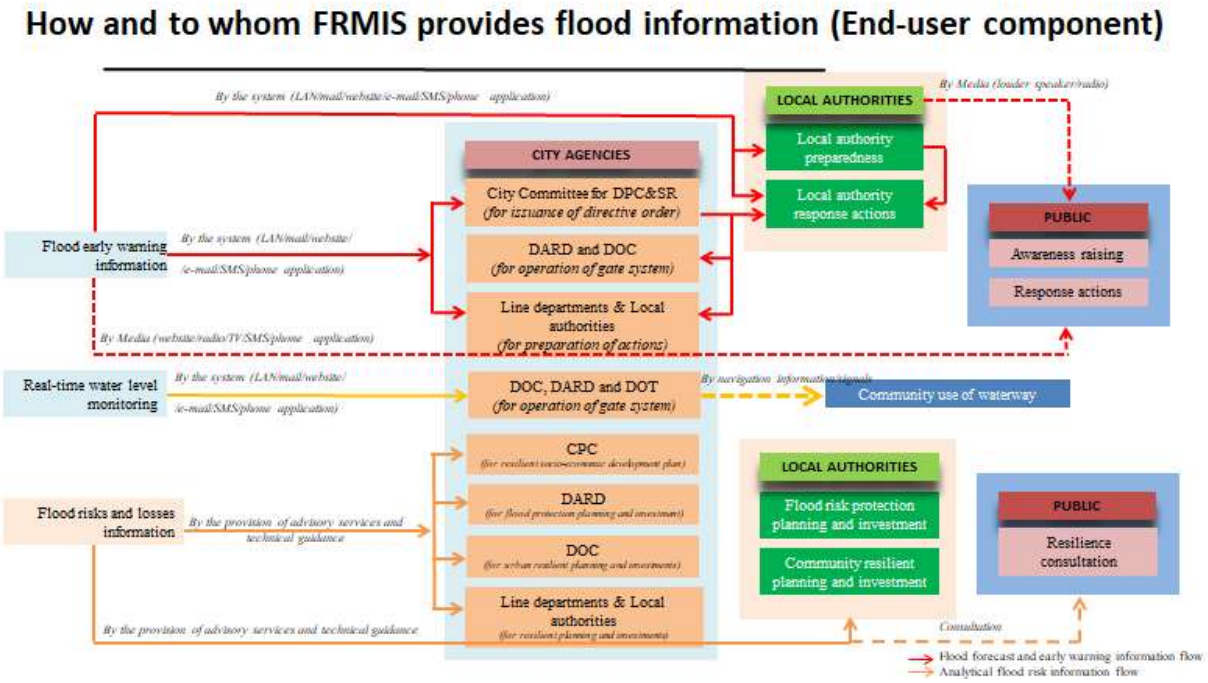


Figure 5. Conceptual design of the operation of the Flood Risk Management Information System (FRMIS

Therefore, successful establishing and operating a FRMIS in any city requires a full achievement of the 4 following key systematic interlinked pillars:

- Pillar 1: Institutional policy and arrangement. This pillar is the master pillar that guide and lead the implementation of all other three below pillars. Refers to the capacity of the city to develop and sustain formal policy, regulatory and governing structures that support geospatial related activities,

and to the role of the city government in fostering the growth of the broader geospatial ecosystem. Activities under this pillar aim to establish enabling mechanisms for inter-agency coordination and, in the long run. These activities span the institutionalization of organization structures such as management steering committee, GeoCommunities etc., and a complete data governance framework. Working collaboratively under the coordination of a city planning agency, a suite of mayoral decrees, protocols, and inter-agency service level agreements are developed. The process of developing these protocols, roles and responsibilities is as important as the outputs themselves for emphasizing collaboration. Organizational structures and regulations established under this pillar address the needs of the other three pillars. Thus, "Institutional Arrangements" is, again, a foundational pillar.

- Pillar 2: Technical skills and capacity. Refers to creating an awareness of capacity needs, identifying gaps in human resource supply, and developing competencies and skill sets for ensuring the effective production, maintenance, and utilization of spatial data. A weak 'People' pillar can limit the development and operation of FRMIS due to a lack of awareness or a shortage of skilled manpower to collect and analyze geospatial information, and to maintain the Geoportal (or integrated data platform) under the 'ICT infrastructure' pillar
- Pillar 3: ICT hardware and software/infrastructure. Refers to any software, hardware, and IT-related infrastructure required to support FRMIS. A key component lies in the adequacy, functionalities and user interface of the city-level Geoportal that combines GIS and spatially referenced tabular data. The Geoportal makes it possible for data sharing decrees and protocols to be actualized.
- Pillar 4: Data. Activities under this pillar assess the current state of data availability and quality, and related policies regarding formats, analysis, and sharing of geospatial information. This diagnostic also considers the business case for investment in data and the extent to which the use of geospatial information can add value to existing line departments' performance.

  From the concept design perspective, the input will consist of rainfall and (river) water level data in and around the city, elevation of the soil and buildings and a detailed description of the infrastructure (embankments, sluices, sewer system). The hydrodynamic model is the core of the FRMIS in which the input data are being processed, using the relevant hydrodynamic equations, to deliver the desired output. The output, finally, is what the various users need (required gate operations for water management in the canal system, water levels on the streets for public warning, water related information for urban planning). There will be two functional sub-system that can be briefed as following:

  FRMIS Real Time (online) sub-system: This sub-system interacts with the SCADA for real time operations of the Tidal flood control infrastructure (tidal gates and pumps) as well as the generation of forecasts and dissemination of early warnings of flooding in the city. This sub-system operates continuously (i.e. is always online), 24 hours a days 7 days a week and utilizes real time measurements from the SCADA sensors and equipment, together with water level and rainfall observations and forecasts in the city area and adjacent rivers.

  The FRMIS Real Time sub-system is responsible for performing two main tasks via the Decision Support Tool (DST). This is the hub of FRMIS Real Time sub-system that provides the interface between the data input and database systems, the control systems, and the analytical tools and models that support decision making. From the DST, information is disseminated to the relevant stakeholders. The two tasks the DST executes are: 1. Providing advice to the SCADA system (either manually or automatically) regarding the operation of the pumps and gate structures based on the WCP adopted for the city; 2. Generating early warning information from modelling in the city area and disseminating this information via web and other platforms.

The SCADA system (available and continue developed) will provide rainfall and water level observations in the whole city area as well as information on pump operation and gate positions of the water control structures and drainage pumps in the city. SRHMC and city rainfall gauges will provide recent observations as well as forecasts of river water levels and rainfall in the city area.

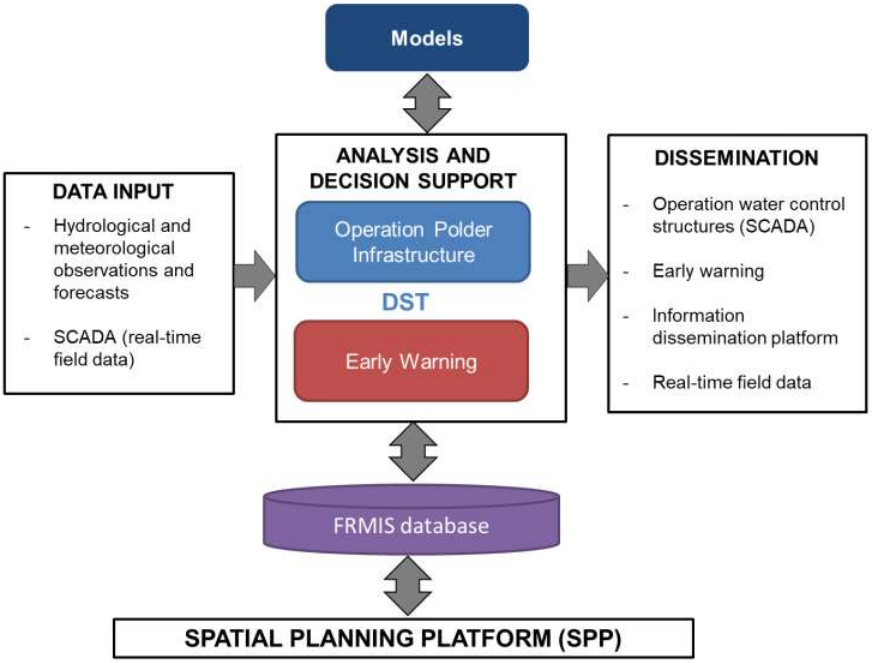


Figure 6. FRMIS Real time sub-system conceptual design

FRMIS Planning (offline) sub-system: In contrast, the off-line sub-system supports longer term flood management and planning in the city. The Risk Mapping component is focused on the production of flood risk maps considering potential economic losses and risks to human life. The Urban Planning Tool as the name suggests is a tool to assist the city authorities to make informed decisions regarding the future development of the city. The offline planning tools utilize statistical hydro-meteorological data to drive the underlying models and generate the necessary outputs. The online real time sub-system and offline planning sub-system share common spatial data sets which, together with the hydro-meteorological data are used to drive hydrological and hydrodynamic models, which in turn provide information on flood levels, flood extents and depths which are then processed by the individual analysis and decision support tools. All data – spatial, time series, model generated – are stored in a common database.

The FRMIS can be used to support departments with their sustainable planning. FRMIS can run the models based on input provided by the departments and prepare flood and risk maps. Flood and risk maps can support the departments with planning of infrastructure or urban planning and city expansion. The FRMIS will provide reports of the results of the modelling, risk maps and when required the results of the urban planning tool to the relevant stakeholders. Envisaged stakeholders that FRMIS can support with sustainable planning:

- CPC: report on flood risk data and related damage costs to be used to prepare the socioeconomic development plan;
- DARD: report with flood risk data and related damage costs for flood protection planning;
- DOC: report on flood risk data and related damage costs to be used for urban resilience planning;

- DOT: report on flood risk data and related damage costs to be used for resilient infrastructure (road / waterway).
  The data required for FRMIS planning leans more heavily on spatial data, in particular data concerning the topography, population distribution, building locations and types, city infrastructure and plans. The SPP will provide the majority of the required data, supplemented by recent census data and other relevant planning documents

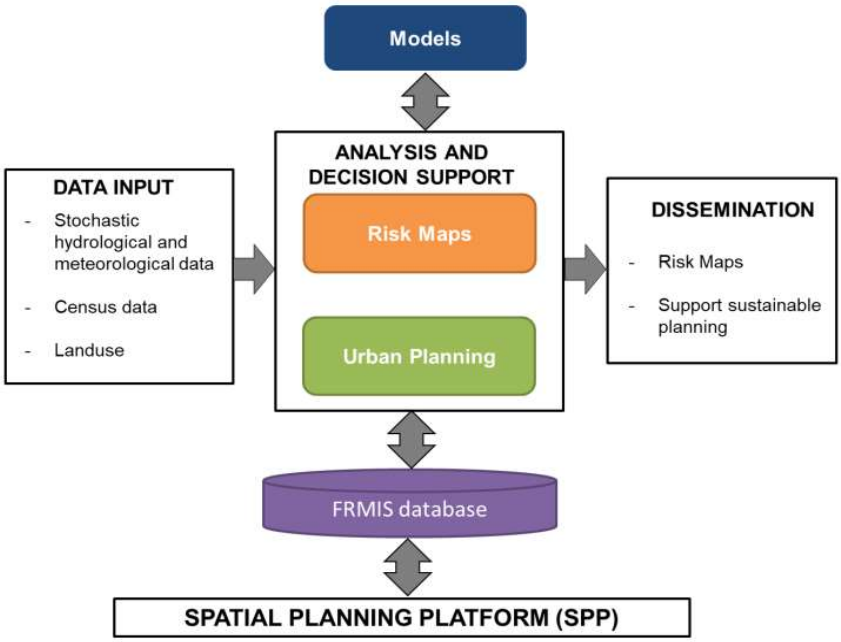


Figure 7. FRMIS Planning sub-system conceptual design

Depending on the city's ability of budget in the recent and/or in the future, the software can be developed in a licensed and/or open-sourced form, while system security is still secured from unauthorized access.

Data is the key requirement for the development and successful operation of the FRMIS. Collectively all data forms a virtual database. In practice this data will be physically stored in a digital database which will also connect to the SPP and SCADA databases.
The base data needed to develop the FRMIS hydrological and hydrodynamic models refers mainly to spatial data. This is essentially static data that does not change or changes slowly over time. Once the models are developed they are "driven" with temporal time series data such as rainfall and water levels. The real time and planning models are essential the same only driven by different types of data. The hydrological and hydrodynamic models require time series data to reproduce historical flood events which are used to calibrate and validate the models.

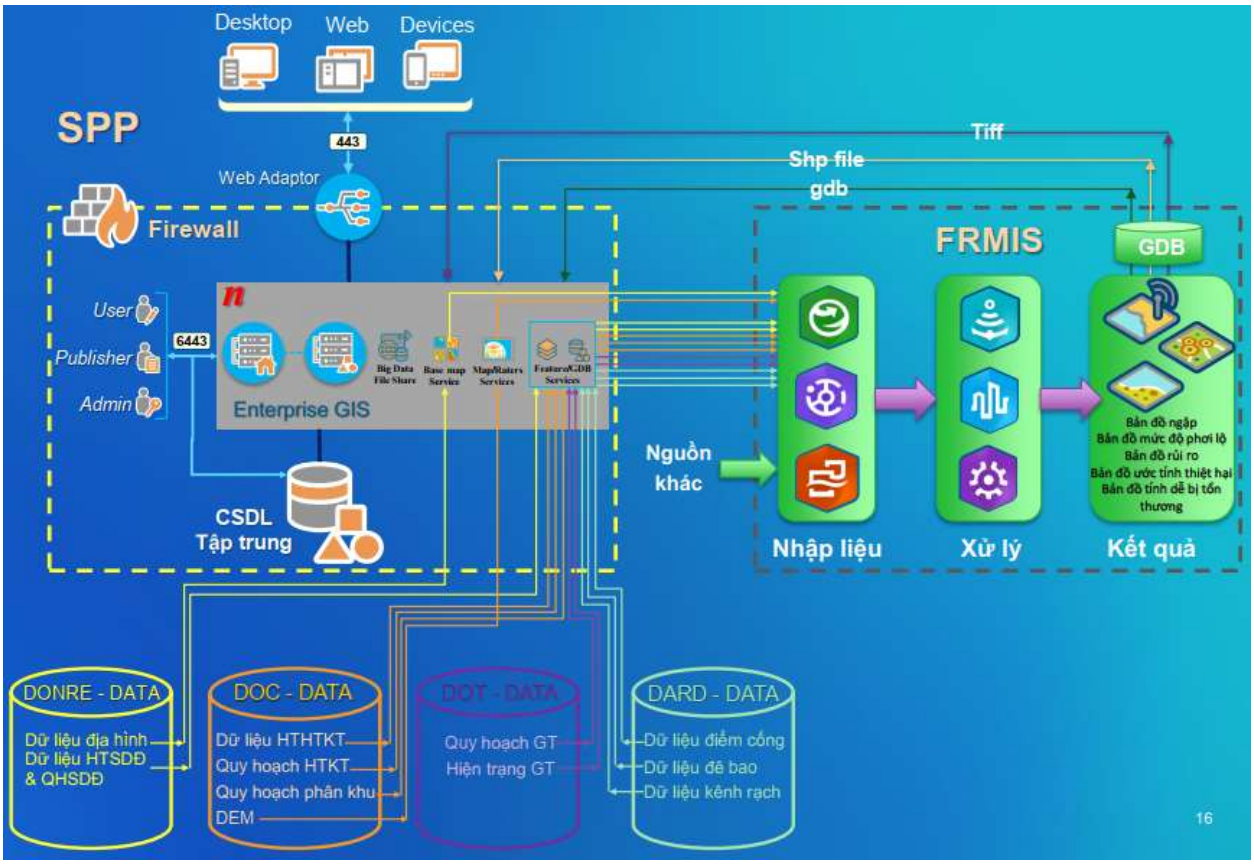


Figure 8. Interaction between SPP and FRMIS (illustration)

CHAPTER 4 – GAPS

In coordination with the City's Department of Information and Communication (DOIC) and Department of Construction (DOC), the World Bank has undertaken a rapid assessment on the institutional setting and data inventory in a short period of 4 weeks in May 2022. The result is being discussed and finalized with the city. Therefore, the analysis is at this stage far from complete and may contain inaccuracies. Details of the assessment can be found in the forthcoming report to be presented and shared with the city.

- Institutional capacity: The Peoples Committee has overall responsibility in the city. Authority is partly delegated to Districts and Wards. Under the Peoples Committee of Ho Chi Minh city (PCC) here is a number of line departments responsible, amongst others, for the water infrastructure, whereby differentiation is made between urban area and rural/ agricultural area.
  Urban infrastructure: In the present situation, the development and operation of urban infrastructure is the responsibility of Department of Construction (DOC). Operation of low level of drainage system is delegated to District Peoples Committees (PC). IMC is a non-business state agency under the DOC which works on behalf of the HCMC People's Committee as the owner and manager of the operation and maintenance of the entire drainage system, tide control facilities, wastewater collection and treatment system and sludge treatment facilities in the city. IMC is responsible for development projects with a budget of below 15 billion Vietnamese Dong (VND). IMC usually contracts maintenance and repair work out to city contractors, the largest of which is UDC. The Urban Infrastructure Construction Investment Projects Management Unit (UICI PMU

manages development projects with a budget of over 15 billion VND and may manage IMC projects with lower budgets. DOC is authorized to manage the activities of the UICI PMU except for the appointment of leadership of the unit and for Level A projects, public-private partnership (PPP) projects and projects using non-budget capital from foreign loans, which must be reported and submitted to the People's Committee for guidance, before issuing implementation decisions. District People's Committees and district service companies act as the owners of the drainage networks in their areas. UDC is the city's public utility company and is charged with the functions of: management, operation and maintenance of the drainage and wastewater collection system; management, operation and maintenance of pumping stations and wastewater treatment plants; construction and repairs of water drainage infrastructures; and treatment of wastewater for the city

Table 1. FRM elements and involved Departments

FRM components	Departments involved
Flood Hazard reduction	
Sewerage system of grade 1 and 2	DOC, DPI, DARD, DONRE, UICI,
Sewerage system of grade 3 and 4	Districts, DOC, DONRE, Urban PMUs
Drainage canal system	DARD, DOC, DPI, DONRE, UICI, TCIP, MOT
Flood retention areas	DOC, DPA, DARD, DPI, DONRE,
Tidal barrier(s)	MARD, DPI, DONRE, DOC
Diking system	DARD, DPI, DONRE
Sluices of the drainage system	DARD, DPI, DONRE, Urban PMUs
Pumping stations	DARD, DPI, DOC
Reservoir operation	MARD, MONRE, DARD, DONRE and upstream provinces
WWT plants	DONRE, DOC, DPI
Vulnerability reduction	
Spatial planning	MOC, DPA and DOC
Land subsidence	DONRE
Flood proofing	DOC, DARD, DONRE
Public awareness	DARD, DONRE
Flood Emergency Management	
Early Warning	MARD, MONRE, DARD, DONRE, CPC
Emergency planning	MARD, MONRE, DARD, CPC, DONRE
Emergency measures	MARD, MONRE, DARD, CPC, DONRE

- **Technical skills and capacity:** The forthcoming data survey and inventory report pointed out several key gaps of the technical capacity of the relevant departments as listed below.

- Most of the surveyed departments and districts (except the Department of Natural Resources and Environment) do not have enough GIS capacity to self-deploy IT application systems, GIS systems.
- Districts and districts are in need of staff strengthening for information technology as well as training for short courses on skills in using GIS data. However, cannot achieve requirements on staff increases to satisfy the demand for IT staff.
- With the current data capability, the City needs to invest in building specialized information systems that allow the application of spatial data into business processes without requiring users to have in-depth knowledge of information technology.

Table 2. Current status of information technology human resources

Name of Department	Number of staff in charge of it	Total number of staff with IT qualifications	Total number of staff with database qualifications	Total number of staff with GIS skill	Total number of staff with short-term GIS training	Total number of staff with map and geodetic qualifications	Level of demand 's satisfaction
Natural Resource and Environment	18	18	13	30			Yet to meet demand
Department of Construction		6		8			Yet to meet demand
Department of Transport	8	7			10	2	Yet to meet demand
Department of Planning – Architecture	2	1	1	2	0	1	Yet to meet demand
District 1	14	11					Yet to meet demand
District 7							Yet to meet demand
Thu Duc	3	1					
Can Gio							

- **ICT infrastructure and data management:** On August 19, 2020, the People's Committee of Ho Chi Minh City issued Decision 3030/QD-UBND approving the project of applying GIS and remote sensing technology in land management, planning and construction in Ho Chi Minh City. The project focuses on a number of contents such as: Building general architecture, detailed GIS system, remote sensing for land management, planning and construction; reviewing, supplementing and updating databases, constructing applications in land management, planning and construction; integration, linking land databases, planning and construction. At the same time, to form an innovative eco-system that applies GIS and remote sensing for sustainable urban management and development. On this basis, the city quickly implemented activities including: preparing information technology infrastructure, building a shared database, implementing data sharing services. sharing through the HCM LGSP Platform, building specialized spatial information

application information systems at the Departments of Natural Resources - Environment, Transport, Planning - Architecture, Construction, Agriculture and Rural development. These applications are developed on information technology infrastructure by Ho Chi Minh City Data Center (HCM Data Center) and Metronet broadband network infrastructure[1].

In 20024, the CPC also established the Geographic Information System Application Center (HCMGIS) under the Department of Science and Technology of Ho Chi Minh City to develop GIS applications in the city. The GIS Center has developed a number of applications in the city in Departments, Boards, Branches and districts, towns. Applications include geographic information platforms with more than 60 layers of data, tourist map applications in districts and dozens of other GIS applications such as infectious disease management systems, vegetable production area management system, distribution system management application, etc. Over the years, the Department of Science and Technology of Ho Chi Minh City has built the HCMGIS Portal, providing a platform for integrating and sharing geospatial data, documents and maps in HCMGIS. The Department of Science and Technology also has many financial and consultant support programs to enable units to deploy GIS applications.

Table 3. List of GIS systems deployed in the city

Name of department	Name of information system	Primrary function
Department of Transportation	Transport information portal	Sharing traffic information, road signs, traffic cameras
	Inland waterways	Management of inland waterway system
	Public transport management system	Public transport management
Department of Natural Resources and Environment	Spatial data portal Geoportal	Support to provide geodata services for background data
	Land information system	Using ViLIS in most of the localities in the city Pilot land management in District 1, District 3 and Thu Duc City on the VDB.LIS platform
Department of Planning - Architecture	Planning portal	Provide planning information
Department of Construction	Flood risk management information system	System is in construction

Although GIS technology is being used strongly, agencies and units still face some difficulties in deploying applications. These difficulties have many causes such as human resources, the capacity of the units is not sufficient to operate the system, as after a period of operation, the systems gradually become ineffective. Some data sources require constant updating while limited resources prohibit units to update data after a period of operation. On the other hand, IT infrastructure as well as software require upgrading after a period of use, making it difficult for implementing units to invest, purchase new equipment, update software and systems per requirements for replacing old technologies.

[1] https://i.hochiminhcity.gov.vn/

In addition, the systems are built separately in each unit, resulting in a waste of investment resources on infrastructure, hardware, and software. Beside, for information systems needing multiple data sources owned by many different units, the units are not ready and qualified to share data, so if separate databases are built, this may result in data deficiencies that cause systems or applications to fail to satisfy user requirements, or duplicated transfer of invested data. To solve the above problem, the City has come up with a strategy to build a shared data warehouse as a pillar to build a smart city[2], in which GIS spatial data is the most important component of this data warehouse[3]. However, the city has also facing some difficulties in data acquisition and digitization, such as:

- Some important spatial data sources such as land data, or non-spatial data such as environmental profile data, construction profile data, digital transformation construction data remains low. The large amount of data makes it difficult to update and requires current correction of maps and cadastral records before digital transformation can be carried out. Land information data lacks the linkage between the attribute data contained in the cadastral records and the spatial data. These are very important spatial data sources with great demand. If digitized and built a database, and shared for other applications, it will contribute to improving the efficiency of public management, as well as contributing to the socio-economic development of the City. However, the investment must be associated with the establishment of a database in accordance with the issued technical standards, at the same time being applied directly to management operation to ensure data is always up to date, avoiding wasteful investment.
- Some data sources established in phases such as planning data, digital transformation data will no longer be valid whenever a new data source is available. The City should consider developing regulations for data delivery so that whenever new data is available, the data is always available in a spatial database format to ensure data continuity.

To have a legal basis city has issued many documents on operating regulations to guide departments and local authorities in digital transformation and data sharing, especially the formation of a shared data warehouse. However, all departments and local authorities have not fully deployed for the data management model to ensure data quality, integrity of the data as well as the process of updating the open data for the shared data warehouse as a data provider. Although, all agencies are properly aware of the data importance and sharing role, and most of the Departments have assigned staff to be responsible for data. The city departments and districts are still facing the following difficulties:

- no data standard regulation is available. It is necessary to develop a common data standard for the city. For specialized data layers that have not been put into shared data warehouses, agencies take the lead in building data structure and content design.
- No clear regulation on data sharing inside and outside the agency, and on ensuring personal information is available. It should develop a clear regulation on data quality, regulations on the responsibilities of organizations and individuals in each department, boards, and districts for data quality as well as troubleshooting during data sharing.

CHAPTER 5 – WHAT CAN BE DONE?

[2] CPC Decision # 6179/QĐ-UBND in 2017 approving smart city programme in 2017-2020, with vision to 2025

[3] Plan # 1008/KH-UBND dated 14/03/2018 regarding to establishment of common data warehouse and open data eocosystem for HCMC

Hochiminh city has specifically choose for the Integrated Flood Management Approach, which considers adaptive measures such as spatial planning, floodproof infrastructure, retention areas… as essential components. Hochiminh city also needs smart tools for urban flood risk management including Flood Risk Management Information system and Spatial Planning support Platform.

Pillar 1 – Institutional Reform and Functional Organization Arrangement

Good governance for Integrated Flood Management requires the following factors to be in place:

- Powerful administrative organization
- Legally embedded (mandate)
- Adequate financing system
- Systematic (planning) approach, and
- Stakeholder participation

Given the fact that institutional reform is always very challenging, and requires a legal form and guidance from the central government. The interim step is to work on the existing institutional arrangement and mandate of the relevant departments and local authorities of HCMC through setting up and formulating a city-formulated policy, called "system operation manual", to guide and change the performance approach from the current fragmented to a systematic and collaborated performance of the relevant stakeholders. This manual will guide who do what and at what stage and how in a systematic chain of actions to ensure all design functions of the FRMIS are operated well as desired. One focal department should be assigned to be in-charged of the system operation. Which means this department will ensure the system operated smoothly, and provide technical guidance and supervision to other involving departments' performance. Having this interim step will build a foundation and synergy for future institutional reform as the need for extension and efficiency of the system will be risen over the course of the system operation.
Therefore, to formulate this policy, the following steps should be proposed to assist with reaching a powerful governance body:

- Analysis of existing institutional landscape in the city, and identification of a focal agency (ideally Doc who is in charge of the urban flood drainage and urban development in HCMC)
- Identification of gaps or doubles in responsibilities among all relevant departments and local authorities versus the requirements for system operation in various design functions
- Formulation of a system operation manual, utilizing the most effective existing capacity and responsibility of the relevant departments and local authorities (without administrative organization required)
- Consultation and discussion with the city to finalize the manual, and it will be adopted by the CPC, and
- Provision of necessary trainings (class and on-job forms) to relevant departments and local authorities on the use of manual or system operation.

Pillar 2 – Technical skills and capacity

Technical skills are required in different levels between the system host department (focal agency) and involving departments and local authorities. The system operation requires a professional unit and technical team established within the host department. This unit/team will be responsible for processing and production of the flood forecasting and early warning, and flood risk modelling to support the decision making process to be made by the responsible departments and CPC. Therefore, technical skills and expertise on flood modelling, meteorologist, hydrologist, GIS, data management and acquisition, software

development and team management are required to be equipped in this unit. Furthermore, technical skills and expertise in ITC infrastructures are also needed to ensure the ICT system runs smoothly.
For the involving departments and local authorities who are the end-users of the system, there are 3 arears of skills/expertise required in each of them: (1) the use of specific software that associated with the FRMIS (e.g. GIS for data uploading and management), (2) the use of risk information in planning and investments, as well as operation of the physical infrastructures, and (3) ICT infrastructure O&M.

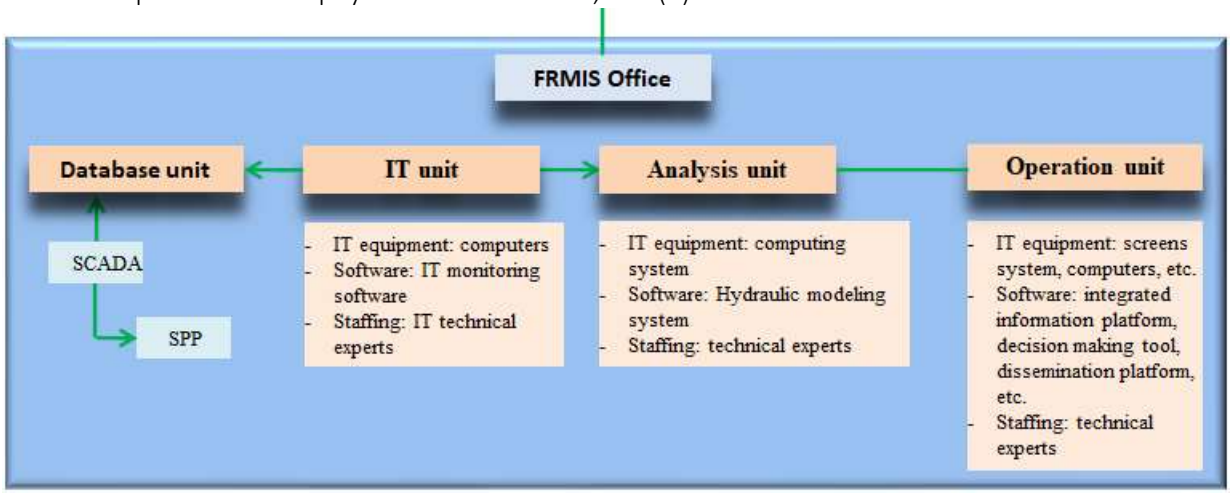


Figure 9. Conceptual design of the FRMIS Office

Scale of staffing in both the system operation unit of the focal agency and the end-users varies, depending on the scale of need using risk information. Initially, number of staff for system operation unit may require from 8-10 experts, and for the end-users may vary from 3-5 experts.

To establish and operate the FRMIS in the interim period, the following activities are proposed:

- Assessment of the technical capacity, including skills, expertise and staffing of the focal and all involving departments and local authorities
- Development of a staffing design for system operation, including the operation design of the FRMIS unit and O&M financial plan
- Mobilization of the technical staffs and provision of necessary technical trainings (class and on-job forms) to these staffs

Pillar 3 – ICT infrastructure and software

Since the city has already developed its ICT infrastructures and tools following the city's decision 3030, but those are fragmented. It's necessary to build an integrator to synchronize and put all existing ICT infrastructures and tools in a system. To serve the integration, several regulations that needs to be put in the place, such data acquisition and standardization, ICT technical specifications, ICT O&M protocol, data sharing and management policy, etc.

HCMC has also developed several databases but managed by different departments. A common databased should be built and consolidated. Such common database can be under the existing Geographic Information System Application Center (HCMGIS) of the Department of Science and Technology, and 2-way synchronized with all existing databases in other line departments, as well as connected to the data sharing and integration platform of the city LGSP (Local Government Service Platform) to provide information and data to people, businesses, and state agencies.

As the FRMIS will also provide city detailed flood forecast and early warning information in the city, extension of the existing SCADA for main water gates and a dense water sensors and hydromet observation network (e.g. rain gauge, combined water level and quality gauges, radar, etc.) will be needed in all key rivers, canals and street networks. This can be installed aligning with the existing hydromet network plan managed by the Regional Hydromet Center based in HCMC.

The following activities are proposed for integration of the ICT network and hydromet network installation:

- In-depth assessment of the ICT infrastructure, including flood morning monitoring and hydromet in HCMC
- In-depth assessment of the existing tools developed by the city (e.g. SCADA, FRM, information portals, etc.)
- Designing of an integrator and a common FRMIS flatform (e.g. hydrodynamic model, integrated flood forecast and early warning, portal interface, etc.) and required standard technical specification for all ICT infrastructures and equipment, and cost estimate
- Designing of a city flood monitoring and hydromet network with standard technical specification and cost estimate
- Procurement of the equipment and installation

Pillar 4 – Data acquisition and management policy

This area should be undertaken simultaneously with Pillar 1 – Institutional Capacity and the database development under Pillar 3. A policy and detailed common guidance on data standardization process, data acquisition and digitization, and data sharing and management will be built upon the existing city's policies and regulations on this area across the departments. Each department can have or developed their own technical guidance for data processing and acquisition depending on their own technical requirements, but they have to be in lined with the developed common policy and guidance.

A subdatabase for FRMIS can be developed within the DOC to enable the flood forecasting and early warning for emergency response and flood infrastructures operation. This subdatabase should has to be synchronized with the common database.

The following activities are proposed to establish the common database and management policy.

- In-depth assessment of the data availability, quality and management policies
- Designing of an integrator for common database, including standard technical specification, subdatabase for FRMIS and cost estimate (in coordinate with the integration of ICT infrastructure under Pillar 3)
- Development of an O&M financing plan for database management
- Development of a protocol and guidance for data acquisition, standardization, digitization and processing
- Development of data management and sharing policy
- Provision of capacity building and training series to line departments and local authorities

Roadmaps and priorities

As highlighted above, the establishment of FRMIS can only be worked successfully when all 4 key pillars are implemented and strengthened simultaneity. In addition, using the FRMIS for an effective and efficiency operation of the flood protection and drainage infrastructure system also requires a completion of such physical infrastructure system. Therefore, under the long-term framework built between the World Bank and HCMC for ensuring the modernization, sustainable and resilient development of HCMC and their

integration in regional economies, it's recommended to embrace the establishment of a city-wide FRMIS in a package of priority investments on physical infrastructure.

In the meantime, this note just suggests a roadmap for FRMIS establishment as in table 4 and rough cost estimate as in table 5 for discussion with DoC and relevant departments.

Table 5. Cost estimate for FRMIS establishment

No.	Activities	Cost estimate (USD)
	International consulting firm for (1) system design; (2) development of hydraulic model and interfaces; (3) supervision of the system deployment; (4) provision of trainings and handover.	5 million
	Physical office renovation	1 million
	Office furniture	0.5 million
	ICT equipment (database, supercomputer, desktops, etc.)	7.5 million
	Hydromet equipment	7 million
	Others	2 million
	TOTAL	23 million

Table 4. Proposed roadmap for establishment of a FRMIS in HCMC

STAGES/ACTIVITIES	PROJECT PREPARATION							INCEPTION	SYSTEM DESIGN			SYSTEM DEPLOYMENT										SYSTEM TEST/ADJUSTMENT				SYSTEM HANDOVER	
								Year 1				Year 2				Year 3				Year 4				Year 5			
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Investment project preparation																											
Pre-preparation for FRMIS establishment																											
1 Rapid data inventory and governance																											
2 FRMIS concept development																											
3 Agreed FRMIS concept and establishment roadmap																											
Preparation to kickoff the FRMIS establishment																											
4 Detailed TORs for FRMIS establishment																											
5 Mobilization of qualifed consulting firm onboard																											
Inception																											
6 Development of a Inception report and Inception workshop																											
System Design																											
7 In-depth assessment (data, policies, ICT, tools, techncial and institutional capacity, needs)																											
8 FRMIS design (ICT infrastructure, options for operational, technical specification and O&M)																											
9 SCADA and hydromet network design																											
10 FRMIS Office layout and design (equipment, staffing, physical space, funitures, etc.)																											
11 Development of a comprehensive training program																											
System Deployment																											
12 Development, caliberate and simulation of detailed hydraulic model for HCM city (1D and 2D), including undertaking of detailed risk assessment to verify the reliability of the models																											
13 Development interface platform for FRMIS (lisened/open-sourced)																											
14 Development of mobile platform for FRMIS (can be used by both experts and public)																											
15 Development of a tool/platform to convert risk into economic losses																											
16 Development of an auttomated information dissemination platform (including web portal, etc.)																											
17 IT equipment purchase and installation for FRMIS Office (in coordination with SPP)																											
18 SCADA equipment purchase and installation (in coordination with the construction of flood structures)																											
19 Furniture purchase for FRMIS Office																											
20 Mobilization of staffs and experts for FRMIS Office and line departments																											
21 Establishment of agreements or contracts with outsourced services for (1) upstream data sharing; (ii) modelling; and (iii) SCADA equipment maintenance/repair																											
22 Development of the system O&M protocol (or Concept of Operation)																											
23 Development of a Water Control Plan (WCP)																											
24 Construction of the flood protection and drainage systems																											
System Test and Adjustment																											
25 Start to undertake training program																											
26 System running and addjustment (if needed)																											
27 Adjustment of the system O&M protocol (if needed)																											
28 On-job training																											
29 IT equipment insurance (if error)																											
System Handover																											

A1. Development of the Flood reporting and Decision Support platform (FEDS)

The initiative Flood reporting and decision support platform for Ho Chi Minh city (hereinafter referred to as the platform) is a technical support of the World Bank (World Bank) and the Swiss State Secretariat for Economic Affairs (SECO) for the Department of Construction of Ho Chi Minh City to contribute to the implementation of the above vision. This initiative is in the framework of the Development Policy Operation (DPO) (i) e-Government and Digital government technical assistance program and (ii) Applied Technology breakthrough in state asset management.

The main objective of the platform is to create a tool for digitalization of data collection, ensuring the systematic storage of data, from which data can be easily synthesized and extracted for reporting, analyzing, and managing flood situations. Besides, the platform is also a channel for the citizens of HCMC to collect and acquire flood information (which has been verified).

The project achieved the following results:

1. Developed and published the applications of the FEDS:

- Mobile app for officer: Báo cáo ngập HCMC (Flood reporting HCMC)
    - iOS: https://apps.apple.com/vn/app/b%C3%A1o-c%C3%A1o-ng%E1%BA%ADp-hcmc/id1568670330?l=vi
    - Android: https://play.google.com/store/apps/details?id=com.hcmc.android.manage

- Mobile app for the public: Bản đồ ngập HCMC (Flood map HCMC)
    - Phiên bản iOS: https://apps.apple.com/vn/app/b%E1%BA%A3n-%C4%91%E1%BB%93-ng%E1%BA%ADp-hcmc/id1568779743?l=vi
    - Phiên bản Android: https://play.google.com/store/apps/details?id=com.hcmc.android.community

- WebGIS for managers: https://flood.gfdapp.net/
- WebGIS for the public: in progress.

2. Technical document of the FEDS

3. Source code of the FEDS

4. Training materials:

- User manual
- User manual (short version)
- Guidance videos for the mobile applications Báo cáo ngập HCMC và Bản đồ ngập HCMC

5. Conducted 3 online training sessions for:

- Thu Duc city (May 27-28)
- DOC, HIMC, UDC (June 3-4)
- 21 Districts (June 17-18)

FEDS implementation plan for 2022:

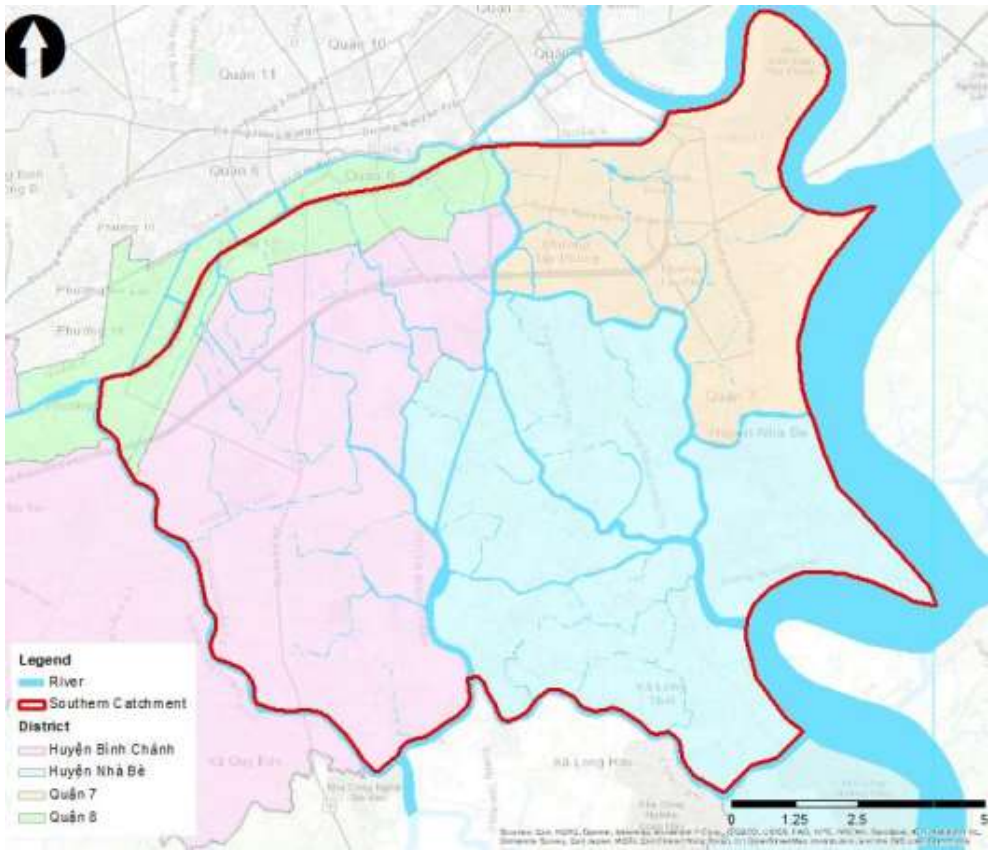
	ACTIONS	TIME
1	Establish FEDS O&M team of IMA (DOC)	04 - 08/04/2022
2	Training FEDS O&M staffs of IMA (DOC)	11 - 13/04/2022

3	Preparation of FEDS O&M Manual	14 - 15/04/2022
4	Training FEDS users for districts	18 - 19/04/2022 21 - 22/04/2022 25 - 26/04/2022 28 - 29/04/2022
5	Implementing FEDS for inundation reporting	T5 - T8/2022
6	Transferring FEDS to the city agencies.	T9/2022
7	FEDS information on Media and Community	T9/2022

A2. Geographical information system for the drainage system in Ho Chi Minh city

The UK Foreign, Commonwealth and Development Office (FCDO) developed a flood resilience intervention for Ho Chi Minh City (HCMC) in collaboration with key city stakeholders as part of the Global Future Cities Programme (GFCP). The aim of the intervention was to develop a Geographical Information System (GIS) database for the drainage system of the city and undertake flood modelling for a portion of the city to enable improved flood risk and drainage management by the HCMC Infrastructure Management Centre (IMC). The key outcomes of the GFCP resilience intervention are:

- HCMC Drainage Database – a standardised GIS database developed for HCMC's drainage network data based on international best practice. Adoption of the HCMC Drainage Database by IMC will drive commonality and better drainage data management, while facilitating realisation of HCMC's Smart City ambitions.
- Southern Catchment flood model – a fully integrated urban drainage model. The Southern Catchment flood model demonstrates best practice in flood modelling in HCMC and enables IMC to make evidence-based flood management decisions. The Southern Catchment flood model provides a benchmark for scaling up of flood modelling across the city.
- Capacity building in GIS and flood modelling – A tailored capacity building programme was delivered including practical workshops in GIS analysis and flood modelling to enable successful adoption of the HCMC Drainage Database and Southern Catchment flood model, and a series of technical webinars by international and local specialists to share experience and drive future connections.
- Documentation of methodology and decision-making processes to enable replication –Intervention outputs including drainage network survey, HCMC Drainage Database and the Southern Catchment flood model were clearly documented in reports, technical notes and guidelines, providing transparency on the decision-making process and enabling IMC to replicate these activities across the city.
- Long-term strategy for GIS drainage management and flood modelling – This will enable IMC to embed the intervention outcomes, supporting future drainage and flood management planning.



Study area

Flood mitigation recommendations

This report presents a methodology for evaluation of flood mitigation options. It is recommended that IMC identify areas with high flood risk based on the Southern Catchment flood maps, with consideration given to any additional information on known flood history or flooding hotspots. These areas should then be prioritised for flood mitigation. Stakeholders including community representatives and representatives of vulnerable groups should be engaged in this process to ensure the needs of vulnerable communities are considered. Mitigation options should be developed, modelled and evaluated using MCA to ensure that multiple benefits are considered in the options appraisal process, such as environmental and amenity improvements, as well as gender equality and social inclusion factors. It is recommended that stakeholders from a range of sectors covering flood risk, GESI, environmental management and city planning are included in this process. Flood mitigation interventions should seek to deliver environmental improvements and reduce inequality where possible; as a minimum, interventions should not increase inequality.

It is recommended that HCMC also considers the adoption of resilience measures. It is not possible to remove flood risk entirely, and it is becoming increasingly difficult under climate change and increased urbanisation. Resilience thinking acknowledges that flooding will occur and seeks to reduce the impact of flooding when it does. There are a wide range of potential resilience measures available, ranging from property-level measures such as raising electrical sockets or fitting non-return valves to drains, to improved emergency response plans and flood warnings systems, and even financial mechanisms such as flood insurance.

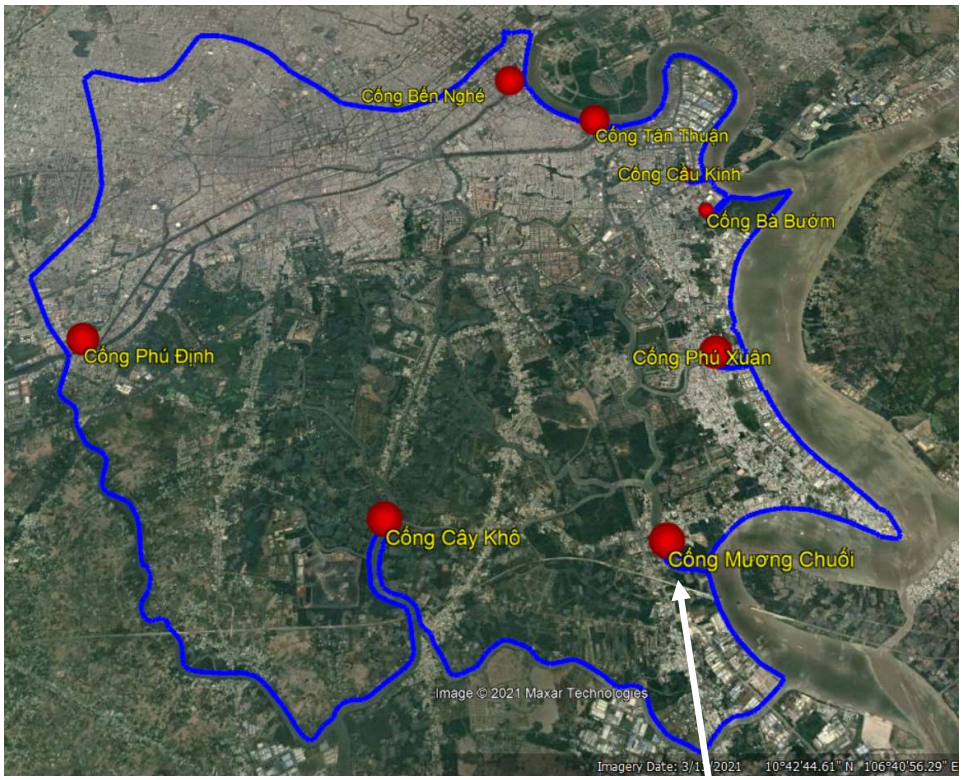
Due to the uncertainty of climate change, it is recommended that an adaptive pathways approach be taken for future long-term planning, in which various strategies are developed for different climate impacts

allowing for easy stepping to the appropriate approach once an understanding of the likely outcome is gained.

Flood modelling recommendations

The IMC staff who attended flood modelling training have a basic understanding of flood modelling, however, additional support in the use of flood models for management may be required to maximise the benefits of the Southern Catchment model. This may include structured or unstructured support by SIWRR or additional workshops on use of flood models for applications such as development planning or mitigation option development. Additional capacity building may also be required for more senior IMC staff with management or decision-making responsibilities, to ensure that the intervention outcomes are considered in plans for future flood management activities. The flood model provides valuable insights into flooding across the Southern Catchment, and in particular, into the functionality of the drainage network in the survey area. This is the only area for which sufficiently detailed and reliable digital drainage data was available for modelling. The survey was undertaken for that specific purpose, with guidance from flood modellers on data requirements. It is recommended that IMC implement the recommendations for maintenance and development of the HCMC Drainage Database provided in the Long-Term Implementation and Operation Plan (PFFC-VN-HR-RPT-5004) to improve their understanding of the drainage network across the city. While integrated urban drainage modelling is recommended, scaling up of detailed flood models across the city will take time, and in the interim period, IMC may use GIS analysis of drainage network data to better understand the drainage network and undertake targeted improvements.

A3. HCMC tidal flood protection project

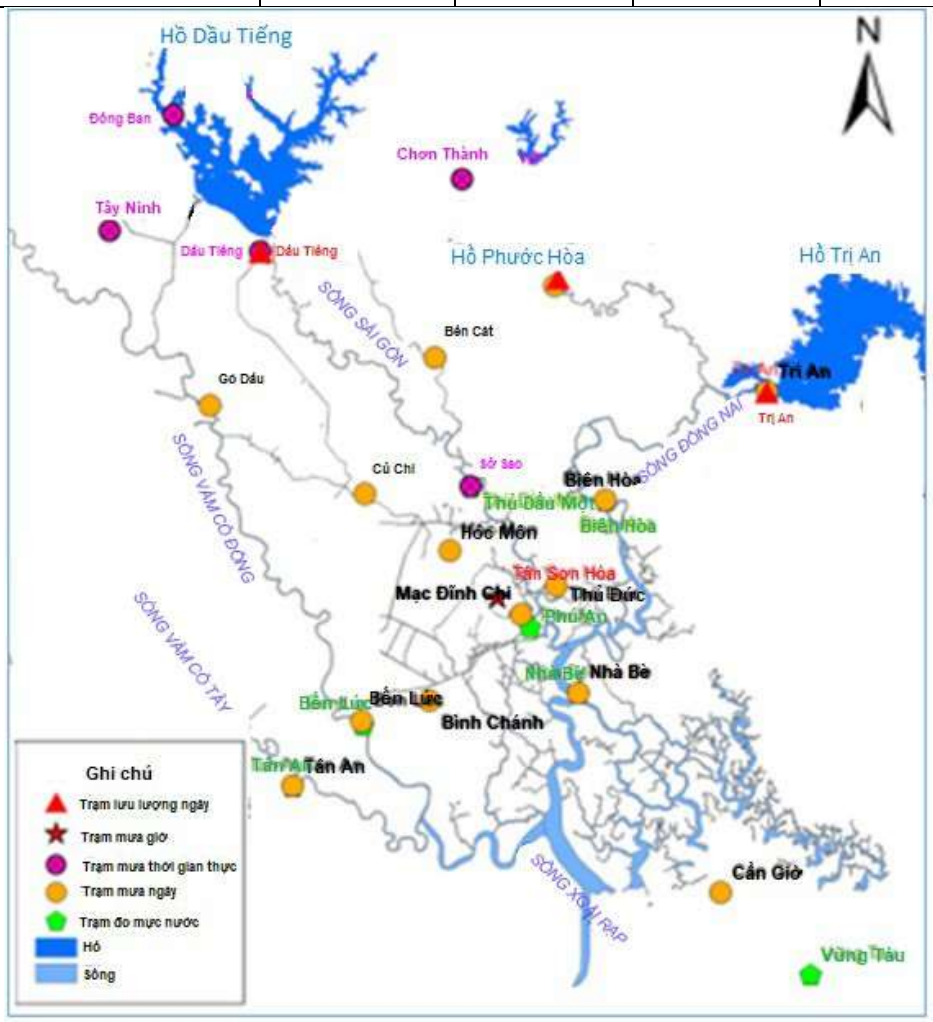


Locations of Tidal gates and Pumps

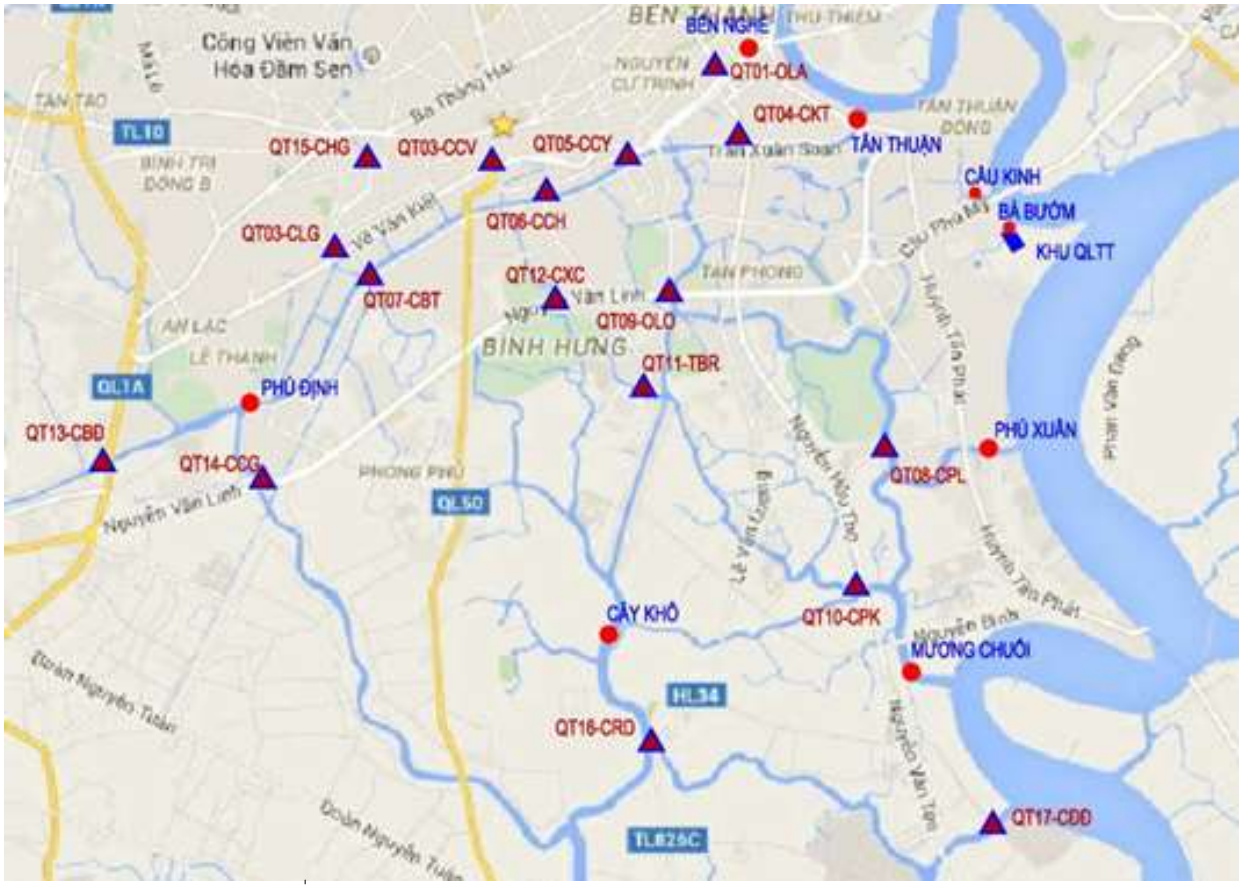
Tidal gates at Muong Chuoi location (4x40m and lock)

No	Name	Tidal gates	Pumps	Locks	Tidal sluices
1	Bến Nghé	x	x		
2	Tân Thuận	x	x	x	
3	Phú Xuân	x			

No	Name	Tidal gates	Pumps	Locks	Tidal sluices
4	Mương Chuối	x		x	
5	Cây Khô	x		x	
6	Phú Định	x	x	x	
7	Cầu Kinh		x		x
8	Bà Bướm		x		x
9	Đê/kè và cống nhỏ				x



Locations of rain record stations and water level gauges in region of Saigon – Donnai river basins



Khoảng cách chiều dọc khoảng 12km

Khoảng cách chiều ngang khoảng 18km

Locations of rain record stations and water level gauges in the city area