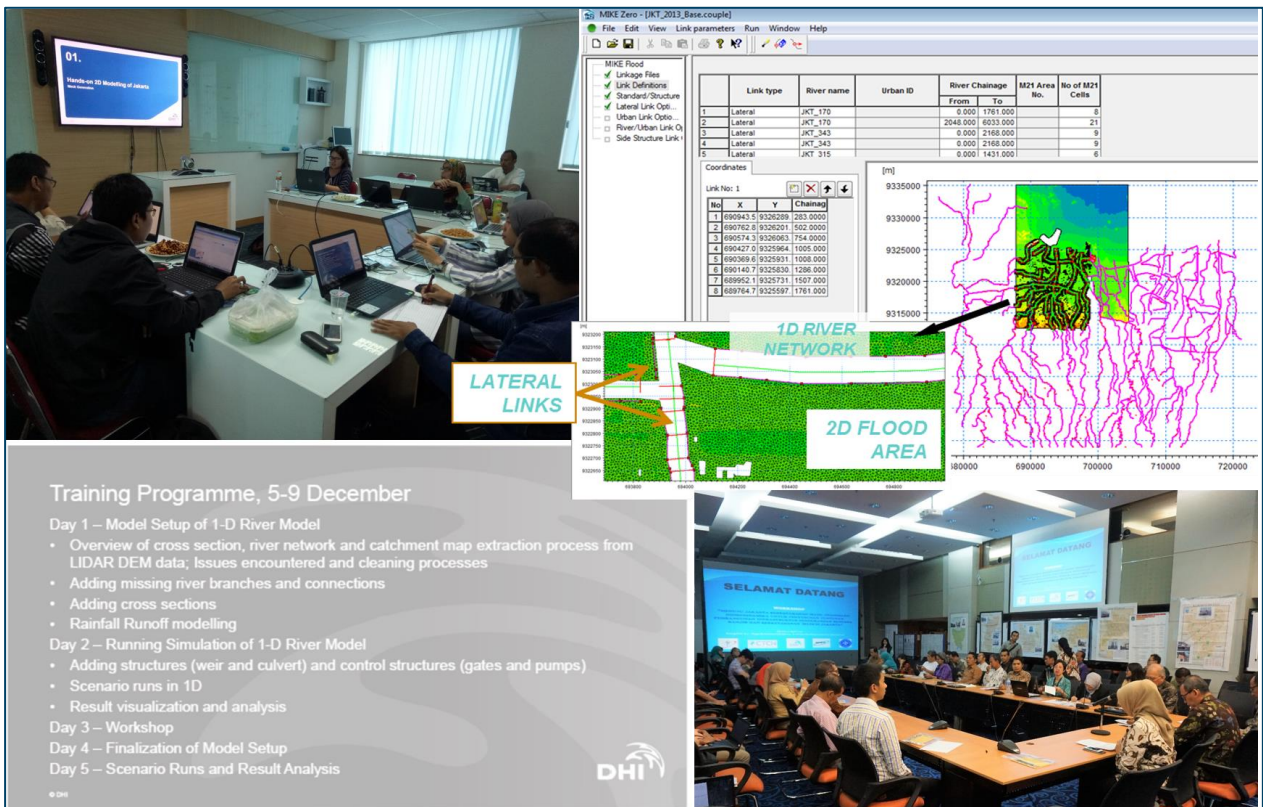


Hydrodynamic modelling for flood reduction and climate resilient infrastructure development pathways in Jakarta

Training and Workshop Summary Report



MIKE Zero - [JKT_2013_Base.couple]

File Edit View Link parameters Run Window Help

MIKE Flood

- Linkage Files
- Link Definitions
- Standard/Structure
- Lateral Link Opt...
- Urban Link Cops...
- River/Urban Link Q
- Side Structure Link

Link type	River name	Urban ID	River Chainage	M2Y Area No.	No of M2Y Cells
1	Lateral	JKT_170	0.000 1761.000		8
2	Lateral	JKT_170	2048.000 6033.000		21
3	Lateral	JKT_343	0.000 2168.000		9
4	Lateral	JKT_343	0.000 2168.000		9
5	Lateral	JKT_315	0.000 1431.000		6

Coordinates

Link No: 1

No	X	Y	Chainage
1	690943.5	9326289	283.0000
2	690762.8	9326291	602.0000
3	690574.3	9326063	754.0000
4	690427.0	9321964	11005.0000
5	690369.6	9325931	11008.0000
6	690140.7	9325830	12386.0000
7	689962.1	9325731	11507.0000
8	689784.7	9325597	11781.0000

LATERAL LINKS

1D RIVER NETWORK

2D FLOOD AREA

Training Programme, 5-9 December

Day 1 – Model Setup of 1-D River Model

- Overview of cross section, river network and catchment map extraction process from LIDAR DEM data; Issues encountered and cleaning processes
- Adding missing river branches and connections
- Adding cross sections
- Rainfall Runoff modelling


Day 2 – Running Simulation of 1-D River Model

- Adding structures (weir and culvert) and control structures (gates and pumps)
- Scenario runs in 1D
- Result visualization and analysis

Day 3 – Workshop

Day 4 – Finalization of Model Setup

Day 5 – Scenario Runs and Result Analysis



This report has been prepared under the DHI Business Management System certified by DNV to comply with ISO 9001 (Quality Management), ISO 14001 (Environmental Management), OHSAS 18001 (Health and Safety Management)



Hydrodynamic modelling for flood reduction and climate resilient infrastructure development pathways in Jakarta

Training and Workshop Summary Report

(Final Draft)

Prepared for CTCN - UNEP
Represented by Ms. Sandra Bry



Project manager	Dr. Budy Wiryawan
Project number	65800016
Approval date	15-05-2017
Revision	1
Classification	Open/Restricted/Confidential

This page is intentionally left blank

CONTENTS

1	Introduction	1
1.1	Objectives	1
1.2	Activities	2
2	Activity Summary	3
2.1	Workshop and First MIKE HYDRO River Training	3
2.1.1	Pre-workshop meeting	3
2.1.2	Workshop and FGD	5
2.1.3	First MIKE HYDRO River Training	8
2.2	Second Training (MIKE FLOOD)	8
2.3	Workshop and Third Training (MIKE HYDRO River)	9
2.4	The Fourth Training and Workshop (MIKE 21 Flow Model FM, MIKE FLOOD)	10
2.5	The Final Workshop (Expert and Stakeholder Meeting)	14
2.5.1	Expert Meeting	15
2.5.2	Stakeholder Meeting	18
2.5.3	Internal Discussion with CTCN representative	21
3	Training material	25
3.1	Pre-processing	25
3.1.1	DEM from LiDAR	25
3.1.2	Drainage Network	25
3.1.3	Cross section	26
3.1.4	Catchment	26
3.2	MIKE HYDRO River	27
3.3	MIKE 21 Flow Model FM	28
3.4	MIKE FLOOD	29
4	References	32

FIGURES

Figure 2.1	The study area in northern part of Jakarta shown in red polygon (Image source: Google Earth Pro)	4
Figure 2.2	Blue-Green Metropolis Jakarta (Sopaheluwakan, 2017)	4
Figure 3.1	Generated river network	26
Figure 3.2	Catchment map from LiDAR data	27
Figure 3.3	MIKE HYDRO interface	28
Figure 3.4	MIKE Flooding approach (DHI, 2016a)	30
Figure 3.5	Coupling of MIKE HYDRO River and MIKE 21 Flow Model FM through MIKE FLOOD (DHI, 2016a)	30
Figure 3.6	Lateral linkage option in MIKE FLOOD (DHI, 2016b)	31

TABLES

Table 2.1	Scenario matrix discussed during the third training and workshop.	9
-----------	--	---

Table 2.2	Scenario matrix of current model	12
Table 2.3	Climate change factors from five GCMs and four RCPs. Modified from Budiyono <i>et al.</i> (2016).....	13

APPENDICES

APPENDIX A – ATTENDANCE LIST OF WORKSHOP AND TRAINING	A-1
APPENDIX B – DOCUMENTATION OF TRAINING AND WORKSHOP ACTIVITIES	B-1
APPENDIX C – TRAINING MATERIAL	C-1
APPENDIX D – WORKSHOP MATERIAL	D-1
APPENDIX E – MINUTES OF MEETING FOCUS GROUP DISCUSSION 28 JULY 2016	E-1

1 Introduction

Jakarta is increasingly threatened by flooding from a combination of land subsidence, rising sea levels particularly with relation to the spring tide cycle and higher river levels resulting from potentially increasing rainfall intensity and land use changes within the catchment areas. Strategies currently defined to address these threats include but not limited to creation of a Giant Sea Wall (GSW) to reduce the risk of flooding and coastal inundation.

The objectives of the Climate Technology Centre & Network (further called CTCN) technical assistance are (i) to better assess flood risks and hazards, and (ii) to design climate-resilient pathways to reduce the magnitude and scale of the impacts from this flooding. This assessment and strategy definition will help shape the design of climate resilient infrastructure projects including, but not limited to, the GSW. The outcomes are (a) a hydrodynamic flood model that can be used to evaluate a number of hard and soft engineering interventions to reduce the risk of flooding (b) a socio-cultural survey to examine inhabitants' perceptions of flooding, levels of acceptable risks and preferred adaptation options, (c) a series of technology transfer workshops to increase local capacity in high resolution hydrodynamic modelling and use of the model, (d) resultant policy and planning recommendations to reduce flood hazards, risk and vulnerability, and (e) a roadmap to sustain and expand the project using additional funding streams.

To meet the expected outcomes mentioned above, the project is divided into the following activities:

- Activity 1 – Flood Risk Assessment
 - Activity 1A – Model development
 - Activity 1B – Sociocultural Risk Assessment
 - Activity 1C – Technology Transfer
- Activity 2 – Formulate Policy Recommendations
- Activity 3 – Developing further funding streams
- Activity 4 – Knowledge sharing and South-South Cooperation

This report will be presenting Activity 1C – Technology Transfer. The technology transfer activity was made to further utilize, adapt and expand the model by local agencies. This activity is expected to increase the capacity building of the local agency especially those that are closely working and associated with flood risk assessment in Jakarta.

Specific aspects of the technology transfer will include flood modelling and hazard mapping. Within this activity, local agencies will be enabled to further develop the model to explore a wider range of scenarios. The training will be done in parallel with the model development activity and will be supervised by local team in DHI Indonesia who are involved in the development of the model.

1.1 Objectives

Through a period of technology transfer including data transfer and training, the model is made to be used by relevant agencies in Jakarta. It is expected that this training should be conducted within four months. Specific aspects of the technology transfer will include flood modelling and hazard mapping. This will enable local agencies to further develop the model to explore a wider range of scenarios.

1.2 Activities

The following section provides an overview of various activities planned under this study:

Workshop and focus group discussion (further called as FGD)

MIKE HYDRO River Training

MIKE 21 Flow Model FM and MIKE FLOOD Training

Final Workshop (Expert and Stakeholder Meeting)

2 Activity Summary

The technology transfer in this project has been done by conducting workshops, FGDs and trainings. The workshop and FGD are mostly aimed to gain the same perception regarding to the objectives of the coordination project between United Nations Environment Programme (UNEP), CTCN, and DHI project as well as to discuss the progress of the tasks. The training that have been done so far are: (1) MIKE HYDRO River training, (2) MIKE 21 Flow Model FM, and (3) MIKE FLOOD training. The participants of this technology transfer activities are DHI, Jakarta Research Council (JRC), Agency for the Assessment and Application of Technology (further called BPPT), and other related institutions/agencies. The participants list in all workshop and training can be seen in Appendix A.

2.1 Workshop and First MIKE HYDRO River Training

The first series of the workshop and training were conducted in three days (27-29 July 2016). Three activities are included in this series, i.e.:

1. Pre-workshop - a coordination / preparation meeting for workshop activity
2. Workshop and FGD
3. The first MIKE HYDRO River training.

2.1.1 Pre-workshop meeting

The pre-workshop meeting was conducted on the first day. The pre-workshop meeting was actually a coordination / preparation meeting for workshop activity on the next day. The meeting lasted for three hours at DHI Indonesia office. It was attended by DHI staff and a representative from JRC.

In the pre-workshop meeting, Dr. P. Suresh Babu as a senior water resource engineer from DHI Singapore have outlined the agenda of the three-day workshop and gave an overview on MIKE HYDRO River that will be used to perform the hydrodynamic modelling. Next, Yus Budiyo, M.Sc., the representative from JRC, gave some feedback to previous presentation and showed the selected location for this study. The study area, shown in Figure 2.1, is the industrial complex in North and West Jakarta province which is identified as a flood prone area. Then he also explained one of the alternative way to solve the flood problem, namely Blue Green Metropolis Jakarta. Blue green metropolis Jakarta is one waterfront city concept proposed by Prof. Dr. Ir. Jan Sopaheluwakan M.Sc., a senior researcher from Indonesia Institute for Science (LIPI) and also a part of JRC, to overcome the flood problem in Jakarta. The visualisation of this blue green metropolis Jakarta can be seen in Figure 2.2. This concept used waterfront city approach that offered vertical settlement and polder at that area. Transportation system that was offered in the concept is the integration of private railway transportation (PRT) and waterway transportation.

Mr. Yus also gave a suggestion to emphasize the urgency of this project for the improvement of Jakarta's future development, in order to make the representative from various institution that was invited in the workshop could give a contribution regarding the data sharing and information.

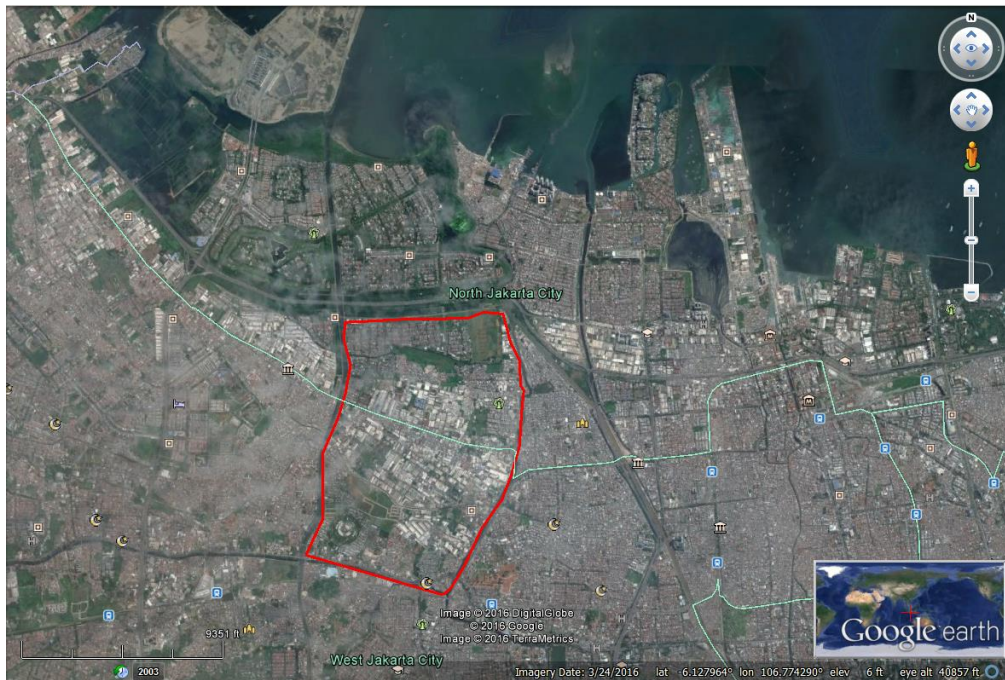


Figure 2.1 The study area in northern part of Jakarta shown in red polygon (Image source: Google Earth Pro)

During the pre-workshop meeting, the participants agreed that one of the questions expected to be answered through this project was how big is the impact of the project to the project area in terms of engineering, social and economy aspects if the Blue Green Metropolis Jakarta city concept is applied in this area, as shown in Figure 2.2. In this meeting, it also has been cleared that the hydrodynamics modelling will be conducted by DHI, but there will be a transfer knowledge activity from DHI (regarding the hydrodynamic modelling) to the JRC.

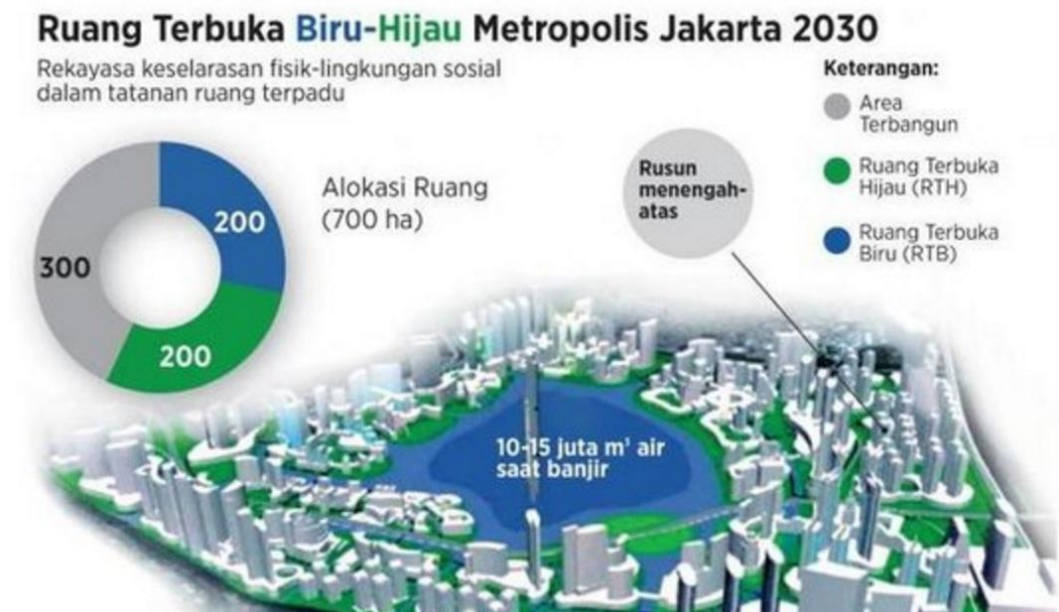


Figure 2.2 Blue-Green Metropolis Jakarta (Sopaheluwakan, 2017)

2.1.2 Workshop and FGD

In the second day (Thursday July 28, 2016), workshop and FGD as series of CTCN project activities was held in Dinas Perumahan dan Gedung Pemda Provinsi Jakarta. The problem statement and the goal of this project has been formulated by the experts that was involved in this project. The workshop was opened by Dr. Ir. Tusy A. Adibroto, M.Si. as representative from JRC. She gave the opening remarks and introduced the general concept of the discussion. She explained that the two main activities from this project will be as follows: (1) high-resolution hydrodynamic modelling for flood analysis and (2) social economic assessment. She emphasized that the final result of this project is expected to be used by the Governor of Jakarta as basis into which a policy will be derived.

The workshop continued with the keynote speech from Ir. Tri Rachmat Djunarro, MM. as representative of Regional Agency for Development Planning (BAPPEDA) Jakarta. He presented the region policy of reclamation and flood disaster management. There are many plans to develop Jakarta for this case, such as: developing facility and infrastructure of polder system and reservoir, integrating the facility from surrounding area (Bogor, Depok, Tangerang, Bekasi), maximizing land utilization with build some vertical housing, and doing some conservation for restricted area and water resource. In his keynote speech, he also explained about the reclamation activity in Jakarta. He said that there are some reasons of doing reclamation of 17 islands in Jakarta i.e. degradation of environmental quality in Northern Jakarta, land limitation in Jakarta, land subsidence, sea level rise and increase of runoff because of construction. In this reclamation project, it is the developer's obligations to provide facility and infrastructure in that area as well as the link inter-new island, and also perform dredging periodically. Besides that, the developer must hand over 5% from total of right of land management.

After the keynote speech, Prof. Jan explained the breakdown of the project. He explained about the work packages that will be included in this project will be about flood risk assessment, specifically activities on (1) model development, (2) sociocultural risk assessment, and (3) technology transfer. The result is expected to be formulated for some policy recommendation. After that, we can develop further funding stream and do knowledge sharing. The key questions and developmental issues in this project are about the climate change impact in Jakarta, the magnitude of risk drivers, some scientific dialog of the problem e.g. climate adaptation policy, rejuvenating the northern coast of Jakarta, reclamation and executing the National Capital Integrated Coastal Development (NCICD) concept, and also about its implementation through policy by the Jakarta government. He also explained about some physical characteristics in Jakarta that had caused flooding, such as groundwater characteristics. Groundwater basin area in Jakarta is different in each part of Jakarta, for example, at northern Jakarta there will be a lot of water because the area are mostly impermeable, and in southern Jakarta there are a lot of absorption area. Prof. Jan also mentioned that the boundaries of catchment area in Jakarta actually extends to surrounding areas (Sawangan, Depok, Cibinong) and therefore contributes to bigger flood waters. There are also some changes to the coastal line of Jakarta due to causes such as longshore current, land subsidence, and climate change. In conclusion, he emphasized that the expected outcomes from this project are (1) hydrodynamic flood model, (2) survey about acceptable risks and preferred adaptation option, (3) technology transfer workshop, (4) policy and planning recommendation, and (5) roadmap to sustain and expand the project.

Next, there are some presentations from DHI, represented by Dr. Budy Wiryawan and Dr. Suresh. Dr. Budy explained about the definition of hydrodynamic modelling and the DHI company profile. Besides that, he also gave a short introduction about the joint UNEP & CTCN program. He explained the mission of CTCN on technology transfer activity, namely: 'Stimulating technology cooperation and enhance the development and transfer of technologies to developing country Parties at their request'. Next, Dr. Suresh presented about hydrodynamic modelling for flood including the importance of modelling

as baseline for decision makers. The flood model in Solo is presented as an example of previous projects conducted by DHI which integrated with the government websites so they can monitor the flood in real time. In his presentation, he also emphasized the importance of good data to produce good quality model and the data required in the project.

After some presentation, the FGD has been conducted to clarify the technical execution of this project. The FGD has been split into two groups, the first group is the hydrodynamics modelling and the second is the socio-economic vulnerability group. The moderator of first group was Mr. Yus from JRC and Pini Wijayanti M.Sc from Bogor Agricultural Institute (IPB) for the second group. The detailed discussion of the FGD is presented in Appendix E.

The FGD from the hydrodynamic modelling group came up with a list of important data needed to conduct the hydrodynamics modelling activities, as well as the availability of the data and potential data sources. These data are mostly scattered in several work units of DKI Jakarta and national institutions. The list of data needed to conduct a hydrodynamic model and their sources are summarised in Table 2.1.

Table 2.1 List of data needed to conduct hydrodynamic flood modelling.

No	Data	Desired file format	Data Authority
1	LiDAR data of DKI Jakarta Area, especially in future project area	Any format recognized by GIS software, (.asc, .xyz, .tif, ESRI grid)	<ul style="list-style-type: none"> Regional Disaster Management Agency of DKI JAKARTA (BPBD) Provincial Spatial planning agency of DKI JAKARTA (DTR)
2	DKI Jakarta (and surrounding) river network: Lines showing locations and connections of drainage network, (rivers, canals, major drains) being studied	Shapefile (.shp)	<ul style="list-style-type: none"> Ciliwung Cisadane Rivers management agency (BWWSCC) DELTARES
3	Cross section of the river network: As-built or surveyed cross-sections of rivers/canals/drains to be included in the model	Excel or CAD drawings	<ul style="list-style-type: none"> Ciliwung Cisadane Rivers Management Agency (BWWSCC) DELTARES Provincial Water Management Agency of DKI Jakarta (DTA)

No	Data	Desired file format	Data Authority
4	Catchment area map	Any format recognized by GIS software, (.asc, .xyz, .tif, ESRI grid)	<ul style="list-style-type: none"> • DELTARES • Provincial Water Management Agency of DKI Jakarta (DTA)
5	<p>River Discharge:</p> <p>very important for calibrating / validating the hydrological (rainfall-runoff) model – preferably from a number of locations around the network, with metadata describing the measurement technique, (e.g. ADCP, rating curve [in which case all curves to be provided], etc)</p>	Preferably as either spreadsheets (.xls/xlsx) or as text files (.txt), with gauge locations provided either as coordinates or in a point shapefile (.shp)	<ul style="list-style-type: none"> • Ciliwung Cisadane Rivers Management Agency (BWWSCC) • DELTARES • Provincial Water Management Agency of DKI Jakarta (DTA) • BWWS, Pusair, Deltares
6	Rainfall intensity	Preferably as either spreadsheets (.xls/xlsx) or as text files (.txt), with gauge locations provided either as coordinates or in a point shapefile (.shp)	<ul style="list-style-type: none"> • BMKG
7	<p>River Structure information</p> <p>Culverts</p> <p>Locations, dimensions, length and invert levels (upstream & downstream) of any culverts present in the network</p> <p>Weirs</p> <p>Locations, crest level, width and shape of any weirs present in the network)</p> <p>Gates</p> <p>Locations, dimensions, and operating rules</p> <p>Pumps</p> <p>Locations, pumping capacity, and operating rules)</p>	Excel or text summary, with locations given as coordinates or in point shapefile (.shp)	<ul style="list-style-type: none"> • Dinas Tata Air DKI Jakarta.
	<p>History of flood data / Previous flood study</p> <p>Any general history of floods in the area</p>	descriptions by local residents, photos of previous floods, slides summarizing the area's flood risk, etc.	<ul style="list-style-type: none"> • Deltares

The data gathering had been followed up by contacting each institution to get the data. JRC will facilitate the legal administration needed for collecting this data.

The FGD from socio-economic group concluded that the proposed location is representative enough, but need more care for applying sampling in the survey. The survey is expected to be conducted using stratified sampling, and some weighting in economic impact study for each district are needed

2.1.3 First MIKE HYDRO River Training

In the third day, the first MIKE HYDRO River training was held as the first stage of technology transfer under this project. DHI has conducted a demo on how to conduct hydrodynamics modelling for flood using MIKE HYDRO River, successor of MIKE 11 software. The activity lasted for two hours, and then followed by informal discussion between DHI and JRC representatives.

During this training, Dr. Suresh presented a brief demo about schematization of drain network and model set up for flood modelling using MIKE HYDRO River software. He showed on how to input Digital Elevation Model (DEM) data to the model set up and how to generate river network and cross section details through the DEM. Then, he showed a sample model results from a model set up using sample model inputs of river discharge and tide condition. A complete tutorial material: module and sample data for this activity was distributed to the JRC representative (Mr. Yus).

After the training, JRC and DHI discussed some topics regarding this project. The first topic was about data gathering and collection. Actually, all data needed is available in Deltares (according to the information from Agency of Ciliwung-Cisadane River Area (BBWS-CC) representative during the workshop activities), and scattered in few government institutions. For this case, coordination between DHI and JRC is needed to contact Deltares in order to get the data. JRC will help in data collection administration. Another topic was about the model scenario and setup, which will be discussed later when data collection is in progress. DHI modelling team also discussed internally to formulate the modelling scheme and scenario. The last topic was about the technical execution of transfer knowledge activity. Dr. Suresh proposed that the transfer of knowledge has to be conducted in parallel with the modelling activities. The JRC/BPPT personnel suggested to do a regular meeting between DHI and JRC/BPPT regarding the transfer knowledge.

2.2 Second Training (MIKE FLOOD)

The second training was conducted on 11-12 Oct 2016 at BPPT Office – Serpong. The training topic consisted of MIKE HYDRO River tutorial and exercise as well as a brief explanation and demo of MIKE 21 Flow Model FM and MIKE FLOOD. The participants of the training were from BPPT and National Bureau for Meteorology (BMKG).

The first day of the second training started at 9 AM and was opened by Dr. Tussy representing both JRC and BPPT. The training itself was carried by Dr. Suresh. He explained the overview of the MIKE HYDRO River software including the purpose of the software, the function, area application, and example of the model results. After that, he demonstrating how to do the flood modelling using the software. The process includes: loading DEM data to the model, creating river network, cross section, the input file (river discharge) from the data, and also visualizing the output file. After the lunch break the

participants were asked to re-do the simulation using the material that was given in the beginning of the training.

On the second day, Dr. Suresh gave another MIKE HYDRO River exercise, i.e. building MIKE HYDRO River model in Salmon River. The purpose of this exercise was to make the participants understand more about MIKE HYDRO River. Before doing the exercise, Dr. Suresh gave a brief tutorial on how to build the model, after which the participants tried to follow in their own laptops. After lunch break, Dr. Suresh explained about Rainfall Runoff module in MIKE HYDRO River. The last topic of the second day training was a brief explanation and demo to do two-dimensional (further called as 2D) inland flood modelling using MIKE 21 Flow Model FM: first by doing Bathymetry and Mesh generation until creating a MIKE 21 Flow Model FM Model. This is followed by a demo on MIKE FLOOD. Then, the training is concluded by some discussion related to the technical execution of the flood modelling.

2.3 Workshop and Third Training (MIKE HYDRO River)

The third training and workshop activity was aimed to follow up the technology transfer activity under CTCN project. This activity was held for five days (5-9 December 2016), starting from 9 AM to 3 PM. The training and workshop was carried by Dr. Suresh as senior water resource engineer and supported by Ms. Fritzi Anne G. Gironella, both from DHI Singapore. This activity also was supported by Ms. Maraya Syifa Widyastuti and Ms. Meirita Ramdhani from DHI Indonesia.

Technical details using real data that have been gathered for the Jakarta River modelling has been explained in the first day of training. This was started with brief explanation of pre-processing of the DEM derived from Light Detection and Ranging (LiDAR) data, followed by delineation of river network and catchment map then the extraction of cross sections. After the presentation of data processing, a demo on how to add missing river branches, connections, and cross sections was conducted.

Technical discussion on developing high resolution one-dimensional (further called as 1D) model, including surface runoff from rainfall data, was presented on the second day of training. Ms. Fritzi and Dr. Suresh gave a demo on how to simulate the Rainfall Runoff model and the 1D river model, as well as how to do visualization and analyses of the results from those models.

Task allocation between DHI and JRC in doing the model setup was discussed on the third day. This task allocation was held as one of the capacity building activities for JRC/BPPT in order to make them more familiarised with the model. Beside task allocation, all parties also discussed about the scenarios that will be simulated in this project. At the end of the session, six to nine scenarios was design reflecting different rainfall and land subsidence conditions. It was discussed and agreed by both parties that the 1D model will encompass the whole Jakarta river network, but the 2D map may be zoomed in to the area of interest, i.e. the polder system mentioned previously.

The scenario matrix designed during the workshop (Table 2.2) is still pending to be finalised, namely: to choose either or both 2012 and 2003 rainfall event depending on rainfall data provided; and whether to include 2050 climate change scenario, which will be included if the rainfall climate change factor is significantly higher than baseline (no climate change factor) condition, or if significantly different with 2100 climate change factor. Hence the number of scenarios will be between scenario six and nine.

Table 2.2 Scenario matrix discussed during the third training and workshop.

Scenario	Flood Event	Tide	Subsidence based from 2012 year – LIDAR DEM
1	01-02 Feb 2007	Actual tide	No Subsidence
2			With negative subsidence (up to 2007)
3	16 Jan 2013	Actual tide	No Subsidence
4			With positive subsidence (up to 2013)
5	21 Dec 2012/ 30 April 2003 *later need to choose one	Actual tide	No Subsidence
6	2050	MHHW+0.375 SLR	No Subsidence
7	(50-year RP+CC Factor)		With positive subsidence (up to 2025)
8	2100	MHHW+0.225 SLR	No Subsidence
9	(50-year RP+CC Factor)		With positive subsidence (up to 2025)

RP – Return Period

CC Factor – Climate Change Factor

MHHW – Mean Highest High Water

SLR – Sea Level Rise

On the fourth day, the training material provided was about adding basic structures, i.e. weirs and culverts, as well as control structures e.g. gates and pumps. On that day, participants were also trained on how to add the cross sections from survey measurements provided by BBWS-CC. The training and workshop on the last day was dedicated for an exercise to finalize the model setup and the discussion about follow-up action for December 2016.

2.4 The Fourth Training and Workshop (MIKE 21 Flow Model FM, MIKE FLOOD)

The fourth training and workshop were conducted to train the participants about MIKE 21 Flow Model FM and MIKE FLOOD. The training and workshop also includes presentations about the initial Jakarta model setup and results, and then to get some input/advise from JRC for updates on the final model. This activity was held for two days (13-14 March 2017) starting from 8 AM to 5 PM at Gedung Teknologi 3, BPPT, Serpong. The opening remarks was given by Mr. Yus as a JRC representative.

The first day was fully consisted of MIKE 21 Flow Model FM and MIKE FLOOD training. The trainer for this training was Ms. Fritzi and was assisted by Ms. Mei and Ms. Syifa from DHI. The training was attended by ten participants that came from BPPT/JRC and BMKG (The participant list can be seen in Appendix A). The training content includes: (1) mesh generation, (2) bed roughness map generation, (3) initial value map generation, (4) setting up MIKE 21 Flow Model FM setup, and (5) setting up 1D-2D coupled model through links in MIKE FLOOD.

The second day was dedicated for discussion. The discussion topics were about: (1) input data and scenario matrix that was used in the current model, (2) overview of 1D and

2D model result, (3) field survey result that has been conducted by JRC, and (4) about flood protection analysis and other future scenarios. In the second day, Dr. Suresh also joined the discussion for about one hour via Skype.

The scenario matrix used in this version of the model was similar with the scenario matrix that was agreed in previous training/workshop, except with the exclusion of 2100 and 2003 scenarios. For climate change scenarios, 2030 scenarios were used, replacing the 2100 scenarios since the latter has high uncertainty. Lack of rainfall data at 2003 rainfall event was the main reason the 2003 scenarios were taken out. The final scenario matrix that will be simulated for this project can be seen in Table 2.3.

In this version of the model, 513 catchments have been generated and used. The total rainfall stations that have been used in current model is 63 stations with different total number in each year: 40 stations for 2013, 51 stations for 2012, 27 stations for 2007, and 10 stations for 2030 and 2050. The rainfall data for 2013, 2012, and 2007 scenarios were obtained from BMKG, while the rainfall data for design storm (2030 and 2050) was 50-year return period rainfall from van der Sleen and Lopez (2013). For 2030 and 2050, the upper 75-percentile of 20 combination of Global Climate Model (GCMs) and Representative Concentration Pathways (RCPs) from Budiyo *et al.* (2016) were multiplied to get the climate change impact (can be seen in Table 2.4). Then, all the daily data were converted to hourly data using standard hyetograph.

Table 2.3 Scenario matrix of current model

Scenario	Flood Event (Rainfall Input)	Tide (Peak Level)	Subsidence based from 2012 year – LiDAR DEM
1	01-02 Feb 2007 (31 Jan-05 Feb)	Actual tide (+0.500 m)	No Subsidence
2	01-02 Feb 2007 (31 Jan-05 Feb)	Actual tide (+0.500 m)	With negative subsidence (up to 2007)
3	16 Jan 2013 (15-19 Jan)	Actual tide (+0.276 m)	No Subsidence
4	16 Jan 2013 (15-19 Jan)	Actual tide (+0.276 m)	With positive subsidence (up to 2013)
5	21 Dec 2012 (20-24 Dec)	Actual tide (+0.286 m)	No Subsidence
6	2050 (50-year RP + 41% CC Factor)	MHHW + 0.375 SLR (+0.610 m)	No Subsidence
7	2050 (50-year RP + 41% CC Factor)	MHHW + 0.375 SLR (+0.610 m)	With positive subsidence (up to 2025)
8	2030 (50-year RP + 33% CC Factor)	MHHW + 0.225 SLR (+0.460 m)	No Subsidence
9	2030 (50-year RP + 33% CC Factor)	MHHW + 0.225 SLR (+0.460 m)	With positive subsidence (up to 2025)

RP – Return Period

CC Factor – Climate Change Factor

MHHW – Mean Highest High Water

SLR – Sea Level Rise

Table 2.4 Climate change factors from five GCMs and four RCPs. Modified from Budiyo *et al.* (2016).

	5 GCM Median	5 GCM Std	upper 68%	upper 95%	upper 75%
2030 RCP2.6	0.79	0.33	1.12	1.45	1.18
2030 RCP4.5	0.76	0.47	1.23	1.70	1.31
2030 RCP6.0	0.79	0.51	1.30	1.81	1.39
2030 RCP8.5	0.85	0.49	1.34	1.83	1.43
2030 RCP Average	0.80	0.45	1.25	1.70	1.33
	5 GCM Median	5 GCM Std	upper 68%	upper 95%	upper 75%
2050 RCP2.6	0.79	0.32	1.11	1.43	1.17
2050 RCP4.5	0.82	0.48	1.30	1.78	1.39
2050 RCP6.0	0.79	0.56	1.35	1.91	1.45
2050 RCP8.5	0.96	0.58	1.54	2.12	1.64
2050 RCP Average	0.84	0.49	1.33	1.81	1.41

For 2030 and 2050 scenarios in this version of the model, the 50-year return period of hourly rainfall was put in the second day of simulation, while zero rainfall was given in the first day of simulation. This point was discussed more since initial value might be a factor that can improve the model. Mr. Yus gave some advice to use the initial values that used in 2007 scenario, since the rainfall data in 2007 was quite high and considered as 50-year return period.

The lack of the rainfall station number in climate change scenarios also became a concern in this discussion. Until this activity held, there were only 10 stations used in 2030 and 2050 scenario, while actually there were 29 rainfall stations for previous climate study conducted by Deltares. For this case, a participant from BMKG (Mr. Alfian) said not all stations that Deltares used came from BMKG, it could be from Research Centre for Water Resource (PUSAIR), while DHI only use rainfall data from BMKG. Mr. Yus suggested to do difference rainfall pre-processing, to accommodate this case, such as using different Thiessen polygon.

The tide used in the model was tidal constituent obtained from Hydrography and Oceanography Agency of Indonesia Navy (DISHIDROS). For 2013, 2012 and 2007 model, tidal data was used directly respective of their time period, while for 2030 and 2050, DISHIDROS tidal statistics value MHHW was used, then added median sea level rise, 0.225-m and 0.375-m respectively. Those sea level rise values were obtained from BAPPENAS (2010). To get worst case scenario, peak tide is adjusted to coincide with peak total runoff.

In second day, some JRC representatives also presented their survey result, including the updated branch, updated pump and structures regulation, and updated polder information in area of interest. There were some branches from current model that did not reflect the real river, such as branch that connects Grogol Lama River to Pesanggrahan River located at north side of area of interest. The important structure that have not

included yet in the current model were: the gate that diverting the water from Grogol Lama to Pesangrahan, some pumps in the area of interest, Warung dam (*waduk*), and Setia dam (*waduk*). These survey results will be considered again and will be implemented to the final model if the structure produce some big effect to the model result.

During the second day of training and workshop, DHI gave some review and suggestions about JRC's previous MIKE HYDRO River model in Sesupe River during the Second Training (MIKE FLOOD) in Section 2.2. One of its review and suggestion was about boundary condition for Sesupe. JRC's model had an empty cross-section that was probably a skipped step of the exercise, causing the model to crash abnormally completion due to model error. Other issues include the use of discharge boundary condition in downstream. The boundary condition in downstream should be water level, i.e. tidal signals, if the boundary is in the sea; but if it is not in the sea, the discharge-water level (Q/h) rating curve boundary condition should be used instead. Secondly, JRC used water depth option for the initial condition. DHI suggested to JRC to be aware of this condition and make sure it presents the reality condition. The other things that should be considered was the time step and cross section. The time step should be not too coarse, and the cross section in a chainage must be adjusted to the cross section at upstream and downstream chainage.

This is the last training from all the training series conducted by DHI in this project. The overall feedback from the participants were satisfactory especially about the training materials provided. The participant also shared on how the training can be improved in other aspects such as the licensing and usage of the MIKE software, dedicated laptops for the training and installation of the MIKE software prior to the session, training venue, and for some, the complexity of the training material especially those not familiar with flood modelling.

The dongles and licenses are given to all participants during the training for the hands-on exercises in the training and one dongle given to the representative of the technology transfer recipient during the whole project period. Some participants shared in the feedback form that they prefer if the dongles for all participants will be given not only during the training period, but also during the whole project period so all of them can practice every day. Some participants also thought it would be better if dedicated laptops were provided for the training instead of using their own laptops/computers, because some of their laptops had problems during the hands-on exercises.

The choice of the training venue can also be better, as some participants shared they prefer to have the training in another place outside of their institution so they can focus on the training session. In this training series, not all participants have a background in flood modelling or in water resource, so that during the training some of them were struggling to understand the material. Additionally, the participants have shared that the training can be improved if a field visit is included, in order for them understand the training material easier.

Some technical issues were also concerning to some participants. The first days of both the first and second training were mostly spent on installing the MIKE software. Some participants preferred to have the MIKE software installed prior to the training session. Some of the participants also expected to have more time in a group discussion.

Despite of technical feedback regarding the training implementation, the training itself has successfully triggered the participant to try learning and building their own model. At the end of the training, the participant were successfully develop a demo model on their own and some of the participant were still in contact with DHI team to check and discuss their model.

2.5 The Final Workshop (Expert and Stakeholder Meeting)

The final workshop was held in two days (20-21 April 2017). The material of this workshop can be seen in Appendix D. Three activities are included in this series, i.e.:

1. Expert meeting
2. Stakeholder meeting
3. Internal discussion with

2.5.1 Expert Meeting

The workshop was opened by Dr. Tusy as JRC representative. She emphasised the importance of this activity and to make Jakarta climate resilient. She also stated that the city should be developed so it will be capable to face future hydrologic problems as consequences of climate change and high water loads of the city. This workshop consist of four presentations and discussion sessions.

The first presentation was conducted by Dr. Suresh and Dr. Budy of DHI team. In their presentation, they explained the purpose of this modelling activity. Dr. Suresh explained the modelling approach as well as the scenarios used in the model. There are nine scenarios that integrate various aspects, i.e. rainfall, tide, and land subsidence. Then, DHI team also explained the modelling activity that has been done, i.e. modelling the area of interest with high resolution (10-m) by using LiDAR data.

From the result, Dr. Suresh concluded some important points, i.e.:

1. The current flood model setup generates reasonable flood maps consistent with increasing rainfall, tide and subsidence.
2. Current flood maps are validated with other models and surveys on 2007 (~50-year return period) and 2013 (~25-year return period) flood events.
3. It is observed that flood is caused more by increased rainfall rather than tide and projected sea level rise.
4. It is also observed that land subsidence significantly worsens the flooding, similar to the findings of previous studies.
5. Further analysis of tidal influence show that coastal flooding from tides is observed only in future land subsidence scenarios (2025 projected ground levels).
6. If a worst-case Climate Change scenario is taken into account, i.e. increased rainfall, the study area is almost fully inundated compared to 2007 flood event.
7. The hydrodynamic model also provides the “weak points” where flood starts to overflow; This will help to mitigate the flood with different options

The second presentation was presented by Prof. Jan. He explained the global concept of this project was inspired from the city planning contest, Blue-Green Metropolis Jakarta 2030. This concept used the waterfront city approach, which offered vertical settlement and polder at that area. The concept also proposed a transportation system that includes the integration of PRT and waterway, with private vehicles prohibited to reduce greenhouse emission.

To follow up the study result, the recommendation/policy brief will be prepared. These recommendations are expected to be concrete/actual actions that will be implemented by DKI Jakarta Governor. They will be related to: a) risk-based city planning, b) urban ecosystem c) city renovation, d) supply chain, and e) replication.

In this project, Prof. Jan also offered polder management concept that integrates three polders, i.e. Pantai Indah Kapuk polder (currently managed by private sector), Kapuk

Poglar polder and Kapuk Muara polder (currently managed by local government). Therefore, there will be more comprehensive hydrology aspect handling by calculating the model result and spatial planning.

The other important issue that Prof. Jan explained was the city/area renovation regarding flood area. This needs to be detailed in spatial study and planning that set socio-economic and infrastructure aspect to be climate change resilient. The other consequence is the need of land subsidence monitoring and solution, such as through law enforcement of ground water extraction.

The next presentation was done by Mr. Yus in which he presented the results from the socio-economic survey. The socio-economic study have been done by three approaches, i.e. macro, meso, and micro study. Macro study was based on secondary data, while meso study was based on FGD. In doing micro study, Mr. Yus also mentioned that the study was based on household survey.

The result of this activity showed various responses from the community regarding mitigation and adaptation. Related to the relocation problem, the community shows the tendency of resistance based on consideration of location, infrastructure, transportation and economic impact. As an alternative to the community, they proposed that the management settlement area and relocate industrial/warehousing area to another place.

The last presentation was presented by Dr. Tusy about the summary from hydrodynamic and socio economic studies as input for policy recommendation formulation. She explained three main points of the recommendation approach which needs to be included for the policy recommendation, i.e.:

1. From hydrodynamic modelling result policy recommendation needs to covered:
 - a. Policy regarding polder management
 - b. Retention ponds location and its pump system
 - c. Land subsidence that related to drinking water service
2. From socio-economic study result policy recommendation needs to covered:
 - a. Socialization to community, related to area environment improvement planning.
 - b. Regulation or technical policy that will developed by government should be started by involving the community, this is related with the tendency of rejection action regarding long-term adaptation.
3. Recommendation for improving previous regulation:
 - a. The regulation for absorption well (this is related to the water runoff constant)
 - b. Operational polder system of 66 polder (macro management) needs to follow province government planning.

Discussion session followed up after presentation session. The discussion session actively involved five participants. The first question came from Dr. Subandono Diposaptono from BPPT. Dr Subandono said that his model is more capable in showing flooding and drying area in the field. He also said that regarding hydrodynamic modelling, the important issue that should be considered was the resolution of the data, i.e. DEM, LiDAR. He suggest to use data finer than 10-m. He also asked whether the model already consider the relation between upstream and downstream. Then he asked about the relation with NCICD/GSW. He expected there are the relation between polder modelling with GSW. The last question he asked is about vulnerability level that can be drawn with vulnerability map, to make other stakeholders understand easier.

The second question came from Mrs. Dewi as representative from Indonesia International Institute for Urban Resilience & Infrastructure (I3URI). She highlighted the main factor/reason why the community rejects the relocation that have been discussed by Mr. Yus, and that this is the main issue that is always raised by the community. She suggest

to do relocation by using 'participatory' approach. To decide the optimum location in community relocation, the study about moving pattern regarding economy activity is needed. From this study, we can get the maximum radius that can be used for relocation location. She also suggest the relocation building should be built not higher than 4-m, to make community still feel comfortable. After relocation process, we need activities to strengthen economy and determine Basic Improvement District (BID) area, so that community empowerment can be done intensively and integrated with other economic policy.

Mr. Fauzal from JRC also participated in the discussion session. He assessed this activity has a challenge in data management aspect, which every stakeholder should record and provide complete data in every time. That is really useful both to improve similar study and to monitor the follow up from future government. He also thought that there is not big scenario in solving Jakarta problem, and at the moment Jakarta need some area reorientation management. He said that the recommendations drawn from this activity should be able to integrate all related stakeholders, since there are a lot of case that only one stakeholder's concerns are addressed. He also said that it is good to have matrix about the relationship between all Regional Government Work Unit (SKPD)/related stakeholders regarding flood and water management.

Another question came from Mr. Novian from BPPT, he asked about the way to determine the respondent in various aspects, i.e. methods, data population, sampling framework, respondent sampling, and error margin.

The last question came from Mr. Wisnu from National Agency for Development Planning (BAPPENAS). He said that PUSAIR from Ministry of General Work had already done the modelling regarding determination of polder location and Jakarta flood, therefore it is good to synchronize the result with them. The ministry cooperated with the Dutch government to do an update and review regarding NCICD. He also said that the Indonesian government already did land subsidence monitoring that have been done by collaborating with Japanese and Thai companies.

In response to the questions raised during discussion, Dr. Suresh said that in order to obtain maximum result/high resolution, 1D and 2D approach has been combined to simulate the model, which 1D approach emphasize in water level aspect in the river. 2D approach described about the spread of the flood, from start point of the overflow water in the river. Regarding the model detail, the resolution of the model is 10-m by using LiDAR data (with resolution 3-m) as DEM data. To simulate the model with finer (higher) resolution, a High Performance Computers (HPC) is needed.

Prof. Jan said the main problem in modelling is not about rainfall modelling, but differential subsidence aspect. The current condition showed that the availability of land subsidence data still limited. The approach of land subsidence monitoring is needed as complimentary material for other hydrodynamic modelling. Prof. Jan also said that the establishment of retention pond is needed to be used to accommodate the 50-year return period flood, but the size and the water volume have not been assessed yet.

Mr. Yus added some response in the discussion, in which he said that this activity was not directly connected to NCICD, because this activity is different especially with its purpose and objectives. In this activity, hydrodynamic model did not cover GSW scenario, due to the fund and activity scope limitation. However, this activity can give some recommendation related to GSW Jakarta. He also said, for vulnerability area mapping has not been done, because the result data has not been gathered yet. After the modelling task is finished, vulnerability analysis can be done based on modelling and socio-economic study result. Then he said that one of the obstacles faced in doing modelling is incomplete data, so there are a lot of assumptions that must be used in the modelling. Regarding respondent sampling method, he suggested to forward the question

to Mrs. Pini, who is in charge of the surveying but is currently in Wageningen, Netherlands and could not attend this meeting. As far as he knows, one survey activity takes one and half days, and this survey is similar with anthropology researches by extracting the information with guidance of survey form.

The last response was coming from Dr. Tusy. She said the input from Mrs. Dewi can added in the recommendations. The result of the hydrodynamic and socio-economic study cannot be directly used to execute the activity, but the gradual and continuous socialization to the impacted community is needed. This study is still limited to the hydrodynamic modelling study aspect, and should be followed up by other activities, i.e. area renovation to improve economic activity in that area. Regarding this issue, Dr. Tusy said that the community already deliberated, but the continuity in deliberation has not been prepared well.

The end of the expert meeting was summarized by Prof Jan and closed by Dr. Budy by stating a short conclusion as follow:

- Land subsidence monitoring is now ongoing
- Based on the fact that some institution is also been doing (or still doing) research which was in line with this project, it would be nice if in the future there will be some kind of public disclosure about what has been delivered by the joint team, so that there will be discussion and brainstorming in the same (government) level.
- The land subsidence problem which caused by ground water extraction, can be solved using clever ways for example by surface water based urban renewal
- Emphasising the importance of data availability to improve the modelling result and also for model calibration and verification.
- This project is a good contribution from UNEP for better Jakarta condition (regardless the existence of NCICD or not) and the result of this project is applicable to who every governor who will lead the city in the next five years

2.5.2 Stakeholder Meeting

The second day of workshop was a stakeholder meeting that was attended by more than 50 people (attendance list can be seen in Appendix A). This activity was held in BAPPEDA Jakarta office at 21st April 2017. The activity was started from 9 AM to 12 PM and was opened by Ir. Tuty Kusumawati, MM. as Head of BAPPEDA Jakarta. She was hoping the result of this project can be used as additional data and information for Regional Medium-term Development Plan (RPJMD) 2018-2020. Then she also emphasized that the policy brief that will produced in this project can be adjusted with the elected governor of Jakarta.

After opening remarks from Ir. Tuty, the workshop was continued with the keynote from Mr. Gunawan as representative from Ministry of Environment and Forestry (further called KLHK). Mr. Gunawan explained the relation between this project and the Paris agreement: there is obligation for developed countries to assist developing countries for climate change mitigation and adaptation.

The workshop continued with presentations. This session was started with the presentation about initial result of Jakarta flood modelling by Dr. Suresh and Dr. Budy. The next presentation was about socio-cultural risk assessment by Mr. Yus. The presentation session was closed with Prof. Jan's presentation, giving an overview on hydrodynamic modelling and social economic changes in Kapuk Polder system.

Dr. Budy and Dr. Suresh started the first presentation by appreciating all the stakeholder who already participated in data gathering process. Next Dr. Suresh presented the modelling and its flood results. The model has a high resolution (10-m) in a pilot project area in Jakarta that is capable of producing flood levels. The steps for hydrodynamic modelling are data gathering and pre-processing, 1D river modelling, and flood modelling, and flood map generation. In this project, DHI already simulated the model for nine scenarios.

Dr. Suresh further explained the modelling approach. The DEM was obtained from integration LiDAR data from Water Management Agency and Shuttle Radar Topography Mission (SRTM). There are also some pre-processing in DEM, such as correcting river network and some LiDAR error. In the model, there are some scenario using land subsidence. The land subsidence data was obtained from Budiyo *et al.* (2016). From DEM data, 513 catchments has been generated for the rainfall runoff model together with data from 63 rainfall station (with different availability in each scenario). The tide that have been used in the model were the actual tide and MHHW values added with median sea level. In 1D modelling, the drainage network and cross section were calibrated with the data from BBWS-CC and Regional Disaster Mitigation Agency (BPBD). Models that have been developed also already included important control structure, such as pumps and gates. Dr. Suresh also mentioned the bed resistance was used in the model was Manning's M, with the value in the pavement was 35, in urban area was seven, and in vegetation and natural area was 22.

In this presentation, Dr. Suresh also explained the model validation by comparing the model result with SOBEK flood map (Budiyo *et al.*, 2016) and flood map from National Disaster Mitigation Agency (BNPB). The flood map from BNPB actually was an indicative map of which village administration unit was reported to be inundated to BNPB by village administrators. The difference of the model can be caused by the rainfall data that used in the model and also different cross sections. Dr. Suresh also presented the result from nine scenarios model. From the result, Dr. Suresh concluded some important points, i.e.:

1. The current flood model setup generates reasonable flood maps consistent with increasing rainfall, tide and subsidence.
2. Current flood maps are validated with other models and surveys on 2007 (~50-year return period) and 2013 (~25-year return period) flood events.
3. It is observed that flood is caused more by increased rainfall rather than tide and projected sea level rise.
4. It is also observed that land subsidence significantly worsens the flooding, similar to the findings of previous studies.
5. Further analysis of tidal influence show that coastal flooding from tides is observed only in future land subsidence scenarios (2025 projected ground levels).
6. If a worst-case Climate Change scenario is taken into account, i.e. increased rainfall, the study area is almost fully inundated compared to 2007 flood event.
7. The hydro dynamic model also provides the "weak points" where flood starts to overflow; This will help to mitigate the flood with different options

Mr. Yus followed up by presenting socio-economic and cultural study. He explained the methodology of this study consist of macro study, meso study, and micro study. Macro study was based on secondary data, while meso study was based on focus group discussion. The result macro study include the density of the population, the database of Small and Medium-sized of enterprises (SMEs) as well as industries. In explaining the result of meso study, Mr. Yus emphasized the three big reasons why the community does not want relocation, i.e. the distance from previous house, private facilities, and monthly rent. In doing micro study, Mr. Yus also mentioned that the study was based on household survey that have been done on 1-12 February 2017. The survey covered 342

household in four sub-district: Kapuk, Kedaung Kali Angke, Kapuk Muara, and Pejagalan. From those three methodologies, some important points can be concluded, i.e.:

1. People who stay in pilot area are vulnerable to flooding. Implementation of public mitigation measures is needed to reduce risk of flooding
2. Relocation to vertical houses is not preferred for households since they have invested their money on multiple private mitigation measures and live close to their jobs.
3. Providing job in the relocation area could increase the acceptance on relocation

After presentation from Mr. Yus, Prof. Jan wrapped up all the presentations by explaining the overview on hydrodynamic modelling and social economic changes in Kapuk Polder System. He said the inspiration of this project was the idea from Green Metropolis Jakarta 2050 competition. Then he said Kapuk polder system was selected because the area continuously subsided and flooded. The existence of non-integrated three polder system also become one reason why this area was chosen.

Prof Jan also explained the project summary i.e. integrated of flood risk modelling and socio-economy risk assessment were expected to be base for some policy brief. In his presentation, he highlighted some policy impact from hydrodynamic modelling and social economy studies, such as possibility of creating combined polder and retention ponds, land subsidence, common understanding on people perception, and the existing regulation in the area.

After the presentations ended, Dr. Tusy (representative from JRC) opened the discussion session. The participants were actively involved in discussion. The first question came from Ahmad Suswito from BMKG. Mr. Ahmad suggested to increase the number of rainfall observation station. He said it will be beneficial to improve the flood modelling. Besides that, he also said the early warning system need to be reactivated to reduce the loss due to the flood. The third thing that he said was this project should be connected with the reclamation issue. Information that the newly elected governor of Jakarta surely oppose the reclamation in Jakarta was also shared.

Mr. Khairul from JRC also agreed with Mr. Ahmad's idea that the designed policy should be adjusted with the elected governor's platform. Besides reclamation, Mr. Khairul also emphasized that Governor-elect Mr. Anies really oppose all activities that need to relocate community. Mr. Khairul said that the flood that had occurred in Jakarta area was related with other areas around Jakarta, such as Bogor, Depok, Tangerang, and Bekasi. Therefore, to reduce the flood in Jakarta, there is a need to control the flood from the other area around Jakarta.

Responding the advice from Mr. Ahmad about flood early warning system, Mr Aditya (Deltares representative) said that Deltares already did joint program with BMKG and PUSAIR about procurement of flood early warning system. The question that Mr. Aditya asked was how to manage knowledge and information that have been gathered to become one knowledge that can be used for everyone.

The other question came from Mr. Junaedi from KLHK. Mr. Junaedi asked how to respond on the flood situation in short term, since there was information from Center of Geology in Bandung that the subsidence in Jakarta is already in the severe level.

Responding to Mr. Aditya's question about how to manage the knowledge and the information, Dr. Suresh said that all the data, even small details, should be shared/ integrated into one place to avoid redoing the activity that already have been done.

Mr. Yus also responded the question and the advice about early warning system. Previously Deltares already did the flood modelling, but agencies are confused on who are have authority to publish the result: BPBD had reservations to deliver the result since they did not know whether the result was accurate, while BPPT wanted to deliver the results but were unsure if they did not have the authority. Mr. Yus also responded to the question about reclamation. He said gathering of the data of reclamation issue should be done.

Then Prof. Jan responded to the question from the participant. Regarding the land subsidence, he said that there will be further flood modelling activity that include the impact of land subsidence. The model will include several scenarios (with and without the retention pond), so from the model result it can be seen whether the retention pond can reduce the land subsidence of Jakarta. Regarding the community relocation in the process of building the retention pond, he already considered that matter. During designing the retention pond, he already allocate some region for the community settlement in various class. For early warning system, he said that agency who have authority to deliver is BPBD Jakarta.

After discussion session, the workshop was closed by Dr. Jukka (CTCN representative) and Mr. Afan (BAPPEDA representative). Dr. Jukka really hope that this project result can give tools and methods that will help to make policy brief. This project also expected to help upscaling the lesson learned, because technical study is not enough and should be continued with action. In the closing remarks, Mr. Afan emphasized the important point is the community relocation should be avoided, and use the word "settlement reorganization" instead. Mr. Afan hoped that this project can produce some recommendation that will be in line with the vision of the newly elected governor. The job program of the newly elected governor can be found in the website: jakartamajubersama.com.

2.5.3 Internal Discussion with CTCN representative

Internal discussion with CTCN representative was held after the stakeholder meeting. The internal discussion was attended by various parties, i.e.: CTCN, JRC, DHI, BPPT, KLHK, and BMKG. The discussion was started by Dr. Jukka's explanation about the latest issue from CTCN.

Dr. Jukka said that the performance of CTCN board was being evaluated regarding the performance and the efficiency in performing technology transfer in the whole world. This activity (hydrodynamic modelling and socio-economic risk assessment) must have impact and benefit for Indonesia, including giving support to the government to produce the policy recommendation. Besides that, he also said that the activity should be followed by concrete action. The concrete action can be supported through several funding schemes from both international funding and by the Indonesian government. For that there must be a road map of activities. Dr. Jukka also reminded everyone that the activity should emphasize the technology transfer aspect, such as technology transfer for local institutions, to continue and develop this activity.

Ardina Purbo, M.Sc. from KLHK stated that KLHK, as National Designated Entities (NDE) Indonesia, was satisfied with the progress of this activity. She expected there will be sustainable follow-up activities. She also expected to adjust the activity result with the new governor's paradigm.

Prof. Jan emphasized that at the beginning, this activity had been designed by considering various aspects, including previous studies and ways to producing the higher resolution result. Technically, this study not only cover northern Jakarta but also covers

the upstream areas by inputting it as a hydrological model, so he expected this study might have better result and can be integrated with studies in other regions.

Beside all the activity that has been done, Dr. Budy said there are some follow-up steps in this project, namely policy recommendation and the scaling up of the application. He also said that this project can be differentiated from other flood projects through the capacity building, data integrated activities and its follow up.

Dr. Jukka agreed with Dr. Budy. Besides, he also emphasized the importance of the reporting. He said that the report is important to document what happened in this work and the result of the project might become beneficial information in the future. The report is also important as a supporting document and basis to arrange the governments' regulation and policy.

After emphasizing the importance of reporting, the topic focused on the climate change adaptation. If climate change adaptation is really a priority in Indonesia, Dr. Jukka said that CTCN can help to facilitate in its implementation. In the last board meeting, CTCN already accepted many projects and proposals, and will discuss further with other NDEs next week. He also asked about Indonesia's priority in development since the country has many development priorities to be done.

Dr. Tusy explained that the results of this project can be used to make evidence-based policies and can be inserted to RPJMD 2018-2022, in accordance with the expectations of the head of Jakarta Regional City Planner office. Dr. Suresh further added that the model developed by DHI for this project will not be propriety to DHI. The model is an open model and can be shared. The capacity building was conducted and it is expected that participants can then run different scenarios that are helpful for their recommendation. If in the future they need some help, they can contact DHI.

Dr. Jukka agreed with Dr. Tusy and Dr. Suresh's statement that Jakarta agencies can use the model result. Dr. Jukka also remind the participants about his statement in previous closing remarks, that Indonesia institution can use the model result and give the information. CTCN can facilitate a discussion regarding this issue with NDE.

Responding to Dr. Jukka statement, Mr. Yus really expect that there will be a follow up activity, such as dissemination and information sharing with other countries. From this project, some information about three polders are already gathered, and it is good to have a meeting to share the knowledge. Mr Yus asked whether DHI/CTCN/UNEP can facilitate this south-to-south cooperation with other countries. Moreover, he asked how long he can use the data and knowledge under CTCN name. Regarding GSW concept, he also asked whether UNEP and CTCN can give support and back up through this activity as a second opinion, aside from the first suggestion that was offered by the Dutch consortium with its NCICD concept.

Dr. Jukka agreed that the information sharing is important, but CTCN will assess the importance of the meeting first. Mrs. Ardina also responded on Mr. Yus' statement by saying that the CTCN project should be distinguished from the NCICD project. The solution for Jakarta has not been decided. NCICD also need to pass some evaluation and assessment. There are also some studies from Korea about the reclamation and which their results were in line with NCICD.

Following the response of Mrs. Ardina, Mr. Yus said that the Korean study was working side-by-side with the consortium of the Dutch consultant. Even if the Dutch consultant already have a verified study, we cannot directly agree with only one party. Another party is needed to have an independent opinion on whether to confirm or not with the Dutch concept. On the other hand, KLHK thought that the important thing is the evaluation and assessment results.

Regarding this topic, Dr. Jukka agreed with both Mr. Yus and Mrs. Ardina's statements. He integrated their statements that the NCICD needed some assessments and evaluations whether to confirm the Dutch's study, and the assessment and evaluation can be from other parties and it should be objective. Dr. Budy also added some insight about this topic, that the result of this project (CTCN) is neutral and objective, with or without NCICD.

Agreeing with Dr. Budy, Prof. Jan emphasized that CTCN project and NCICD project is different, but those projects are relatable in the hydrology aspect. We can integrate the solutions derived from both studies, e.g. the use of system polders and retention ponds plus GSW. Compared to NCICD, CTCN have different approach, CTCN approach is to solve the problem at the land side by recharging the wet land through building retention ponds.

Dr. Suresh concluded the topic that the flooding in Indonesia (Jakarta) is a complicated problem caused by various factors, such as rainfall, sea level rise, land subsidence, and the problem from river network. It may need multiple solutions and approaches because one approach might not solve the problem 100%. Retention pond is good but may need a combination of solutions. The GSW, retention pond and polder system may be a possible combination. Dr. Jukka agreed with Dr. Suresh's statement, saying from this project we can give advice and choice of the regulation.

Another topic of this discussion is about the modelling and the capacity building. Mr. Ahmad suggest to do model approach from both upstream and downstream by inputting the rainfall on the whole of Jakarta and around Jakarta area. So we need to collaborate with the governments of all areas around Jakarta: Bogor, Depok, Tangerang, Bekasi. He also added that for technology transfer, it is better to involve the representative from Jakarta government including all Jakarta agencies and ministries.

Responding to Mr. Ahmad's statement, Dr. Tusy said that from previous trainings, there were BPPT and BMKG staff, and will hold one capacity building for SKPT. Dr. Suresh also responded that the modelling work already included rainfall from the upstream and is implemented in the current 1D model.

The last topic that was brought up in the discussion was about licenses of the MIKE software. Dr. Tusy said that the CTCN project only has one year duration and the license of the software will be expired by the end of the project (20 June). Dr. Tusy asked whether it is possible for the license to be extended until December. Dr. Suresh responded that if the license will be extended only until December, it will have the same issue when December comes. He suggested that it is better to have the full license. Dr. Jukka agreed and regarding the license, he will discuss it again with DHI as CTCN consortium partner.

At the end of the discussion, Prof. Jan concluded that:

1. The activity got a good response from Jakarta government, and they expect that the result can be used for policy recommendation
2. The project team still have to finish some task, and there are two following activities, namely policy recommendation and upscaling the application
3. Need to socialize the result with other country. Dissemination with other country will be discussed again later
4. License issue will be discussed and will be follow up through the next discussion by CTCN, JRC, and DHI
5. Regarding NCICD, CTCN project can be integrated to that study
6. Upscaling the application can be started in Jakarta, and similar places.

This page is intentionally left blank

3 Training material

Training materials from the four training session consisted of theory, module, and study case of MIKE HYDRO River, MIKE 21 Flow Model FM, and MIKE FLOOD. In addition, the training material also include pre-processing before modelling was done. Some presentation slides during training activities were enclosed in Appendix C.

3.1 Pre-processing

The data that have been gathered cannot be directly used in the model. There are some data processing before do the modelling. In these trainings, the trainer also gave a brief explanation about this process. The process included processing LiDAR, drainage network, cross section, and catchment. For more detailed information about pre-processing of the modelling, please refer to this report's partner paper "Hydrodynamic Flood Modelling Summary Report" DHI (2017).

3.1.1 DEM from LiDAR

DEM data will be used to generate the cross section, river network and catchment definition. The current DEM used in this project is based on the LiDAR data of year 2010 (with resolution of ~1.33 m), provided by the Water Management Agency (DTA). The pre-processing that have been done were:

- Extending the coverage of LiDAR data by filling the data gap with ALOS 30-m and SRTM
- Reducing noise and spikes from the fine resolution images captured by LiDAR. This was done by resampling the DEM from 1.33-m to 3-m resolution. Further impediments inside the rivers, e.g. bridges, debris, sedimentation, were removed to ensure correct drainage delineation.
- Applying "Hydro enforcement" in the DEM, where we have defined river networks and enforced the flow paths in the DEM (which has been provided, as discussed in the next section).

3.1.2 Drainage Network

From final drainage network, there are about 147 branches that have been generated (can be seen in Figure 3.1), including almost all important rivers that flow in Jakarta province, as well as the rivers from surrounding area that are still integrated in the catchment area. The pre-processing that have been done in generating drainage network map were:

- Delineating the river and catchment using LiDAR DEM and then calibrated by the drain network that has been given from the BBWS-CC and also the river map of BPBD which available in petajakarta.org
- Further verification of the generation river network was done to ensure that complex networks are captured in the model, such as drain canals connecting two rivers which are otherwise not captured during the DEM-based river and catchment delineation
- Excluding the river branches upstream of the model network but are included in Greater Jakarta catchment, since cross-section cannot be extracted beyond the extent of the LiDAR DEM (further discussed in the next section). However, the

rainfall-runoff for the whole catchment areas was used to refine the boundary conditions at the South of the model river network.

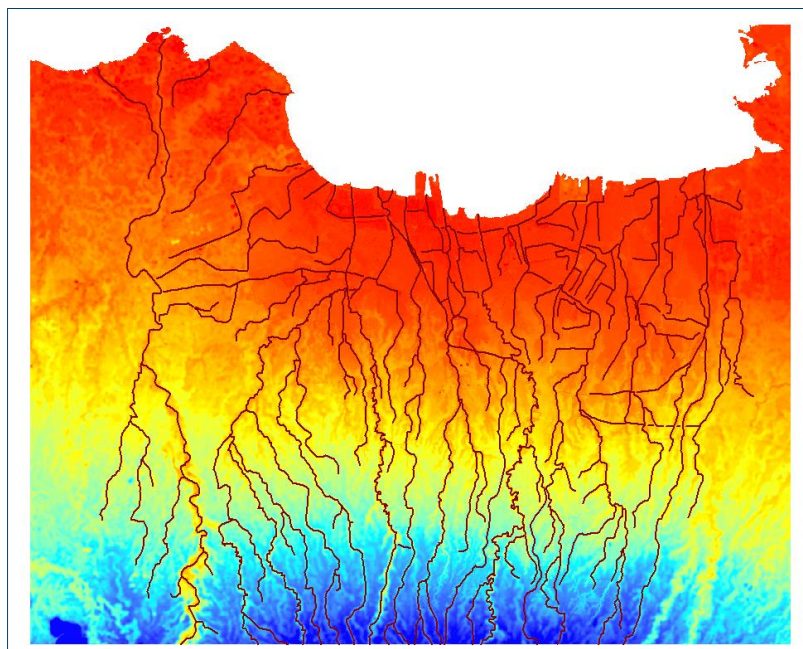


Figure 3.1 Generated river network

3.1.3 Cross section

The pre-processing that have been done in generating cross section include auto-generation extraction from LiDAR data and calibrated with survey cross section from BBWS-CC.

Generating cross section from LiDAR data. First version of river cross-sections are extracted from the elevations provided in the Jakarta DEM, with 3-m data points at each width. Since LiDAR cannot penetrate water bodies to get actual river bed/invert levels, only the cope levels, bank/levees and floodplains are extracted from DEM, and the drain cross-section areas are calculated from Manning's equation. Generally, the discharge of a cross-section is scaled based on its catchment drainage area, and so the cross-section area is largely based on their locations at the catchment i.e. upstream = less catchment area = less river discharge = less cross-section area and vice-versa. Slope can be calculated directly from DEM to complete the equation

Prior to the calibration of the overall cross section generated by the LiDAR data, the cross section data from field measurement is converted from the AutoCAD format to MIKE HYDRO River format. At this moment, the cross section is still in calibration process. In addition, only survey measurements at Angke, Cengkareng, Ciliwung, KBB and Krukut rivers can be used in the MIKE HYDRO River model.

3.1.4 Catchment

For final catchment, there are 513 catchment that have been generated Figure 3.2. The pre-processing in generating the catchment were:

- Generating catchment from final DEM data.

- The catchment parameters such as runoff coefficients and time of concentration are derived from the DEM and public-access global maps for Land Cover (ESA GlobCover v2010, 300 m) and Soil (Harmonized World Soil Database v1.2, 30 arc-second).

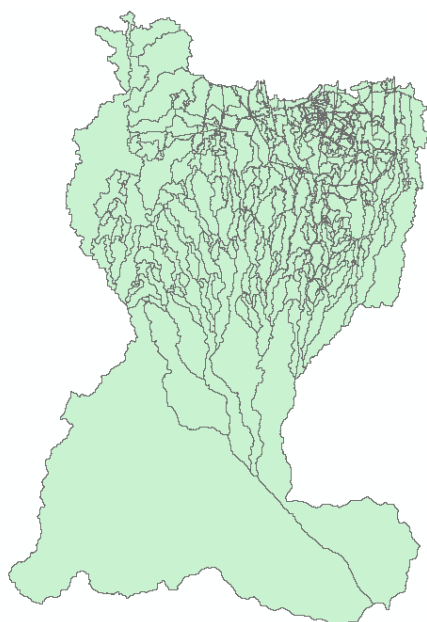


Figure 3.2 Catchment map from LiDAR data

3.2 MIKE HYDRO River

The DHI 1D model, MIKE HYDRO River, is capable of simulating channel flow in common drainage structure such as culverts, weirs, gate operations, etc. The MIKE HYDRO River model schematises the significant river network as 1D channels, as well as simulating the rainfall-runoff process as detailed input to this network. The rainfall-runoff processes are simulated by the Rainfall-Runoff model (further called RR model). Therefore, the 1D model consists of two primary components:

- Hydrological model: simulating rainfall-derived runoff into the river network
- Hydraulic model: simulating water levels and discharges throughout the river network

Catchment runoff is proposed to be estimated using the Unit Hydrograph Model (UHM). The Unit Hydrograph approach applied by MIKE HYDRO River is a single storm event model with parameters directly related to the physical characteristics of the catchments. As such, the model is particularly adapted to simulate the hydrological conditions of an existing catchment without gauging data or to simulate future land-use scenarios. The model divides the storm rainfall in excess rainfall (runoff) and water loss (infiltration), described as follows:

- Runoff: The SCS dimensionless hydrograph is derived from a large number of natural unit hydrographs from catchments of varying size and location
- Infiltration: Infiltration is calculated as a proportional loss from the rainfall input, employing the Runoff Coefficient and Lag Time that characterizes the catchment in terms of soil type and land use

With its intuitive, user-friendly interface, MIKE HYDRO River provides advanced facilities for the input of necessary data, as well as the review and presentation of results. A screen shot of in the MIKE HYDRO River interface is provided in Figure 3.3, showing the modelled river network and catchment map, sample cross-section at Cengkareng, and sample boundary conditions of highest Tide and 100-year rainfall-runoff.

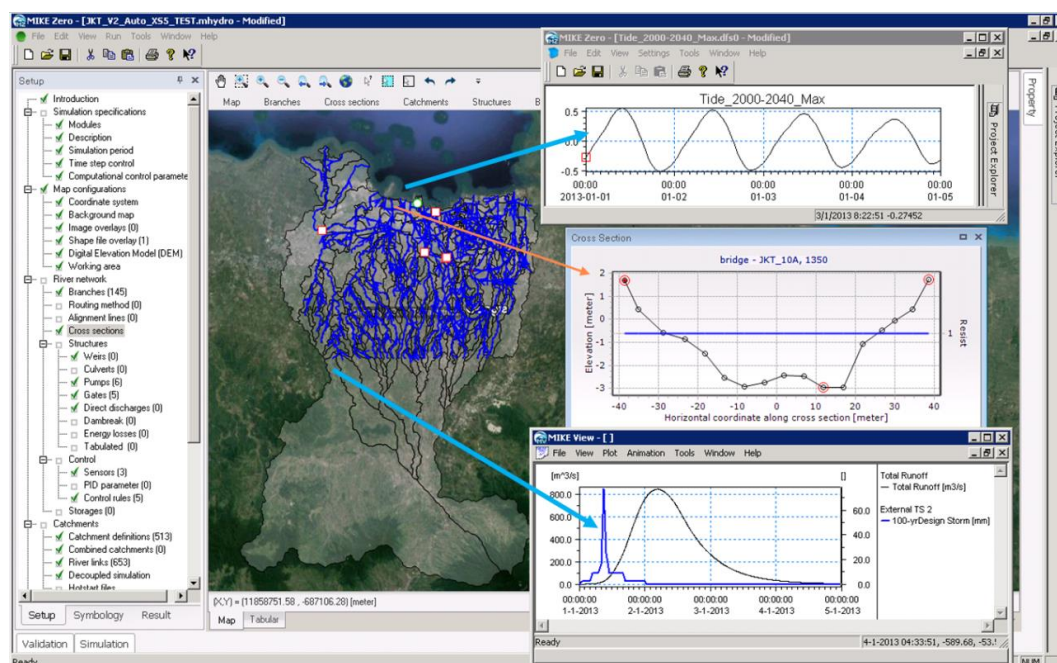


Figure 3.3 MIKE HYDRO interface

In the trainings that have been done, these are the topics that has been explained to the training participant:

- MIKE HYDRO River Concept
- Theoretical background to 1D river hydro dynamic modelling
- Data requirements for 1D modelling
- Introduction to the MIKE Zero GUI, Tools and Project Explorer
- Modelling basic hydraulic structures
- Presenting and Analysing simulation results (MIKE HYDRO River and MIKE View)
- rainfall runoff modelling, calibration and validation
- Stability issues in 1D modelling

Beside the explanation of topics above, participant also did hands-on exercises and did some study cases. In the first training, the study case that were used is the basic one in Sesupe river. Besides continuing the standard modelling exercise of Sesupe river, the participants tried to model Salmon trout river in second training to integrate it with MIKE 21 Flow Model FM and MIKE FLOOD. Since the data already gathered in the third training, the study case in the third training is located in project location (Jakarta) by using the real data.

3.3 MIKE 21 Flow Model FM

DHI's 2D model, MIKE 21 Flow Model FM, is used to identify the level of inundation arising from coastal and inland inundation and any residual overland flow identified from the 1D model. The 2D model is capable of modelling the flow of water on land and through common urban features by using flexible mesh (FM) as its computational grid.

MIKE 21 Flow Model FM is a modelling system for 2D free-surface flows. MIKE 21 Flow Model FM is applicable to the simulation of hydraulic and environmental phenomena in lakes, estuaries, bays, coastal areas and seas. It may be applied wherever stratification can be neglected. The hydrodynamic (HD) module is the basic module in the MIKE 21 Flow Model FM. It provides the hydrodynamic basis for the computations performed in the Environmental Hydraulics modules.

The application areas are generally problems where flow and transport phenomena are important with emphasis on coastal and marine applications, where the flexibility inherited in the unstructured meshes can be utilized.

The use of flexible mesh in MIKE 21 Flow Model FM offers flexibility in resolving the geometry. When necessary, the triangular and quadrangular elements can be combined to allow resolution of channelized flows with quadrangular elements, such as the incised main channel seen clearly running east of the eye of the spur. High resolution in the main area of interest will be schematized with the DEM provided. Coarser horizontal scales can be utilised for areas outside the immediate area of interest.

The modelling system is based on the numerical solution of the two-dimensional shallow water equations - the depth-integrated incompressible Reynolds averaged Navier-Stokes equations. Thus, the model consists of continuity, momentum, temperature, salinity and density equations. In the horizontal domain both Cartesian and spherical coordinates can be used.

The spatial discretization of the primitive equations is performed using a cell-centered finite volume method. The spatial domain is discretized by subdivision of the continuum into non-overlapping element/cells. In the horizontal plane an unstructured grid is used comprising of triangles or quadrilateral element. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible to handle discontinuous solutions. An explicit scheme is used for the time integration.

In the trainings that have been done, these are the topics that has been explained to the training participant:

- MIKE 21 Flow Model FM concept
- Mesh generation
- Initial value map generation
- Manning (bed resistance) map generation
- Setting up the 2D model with MIKE 21 Flow Model FM
- Presenting simulation results

During this training, participants already used the actual Jakarta data that have been gathered. Participant also did some hands on after trainer gave some explanation.

3.4 MIKE FLOOD

MIKE FLOOD is the most complete toolbox for flood modelling available. It includes a wide selection of 1D and 2D flood simulation engines, which enables modelling virtually any flood problem - whether it involves rivers, floodplains, floods in streets, drainage networks, coastal areas, dam, levee and dike breaches or any combination of these. The basic MIKE FLOOD model schematization to be used for this study is presented in Figure 3.4

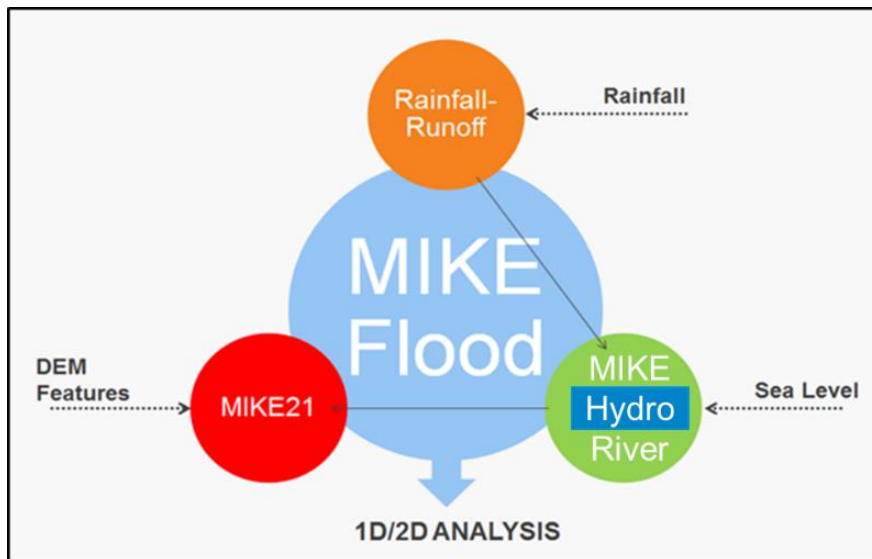


Figure 3.4 MIKE Flooding approach (DHI, 2016a)

Figure 3.5 presents a visual impression of a coupled MIKE HYDRO River and MIKE 21 Flow Model FM model using MIKE Flood. The modelled river network, extending from the top of the image down, is schematized as 1D branches using MIKE HYDRO River, while MIKE 21 Flow Model FM is used to model the coastal area in the lower half of the image, indicated by the 2D grid. These two models are coupled at the coastline at two locations, as shown by the green boxes in Figure 3.5.

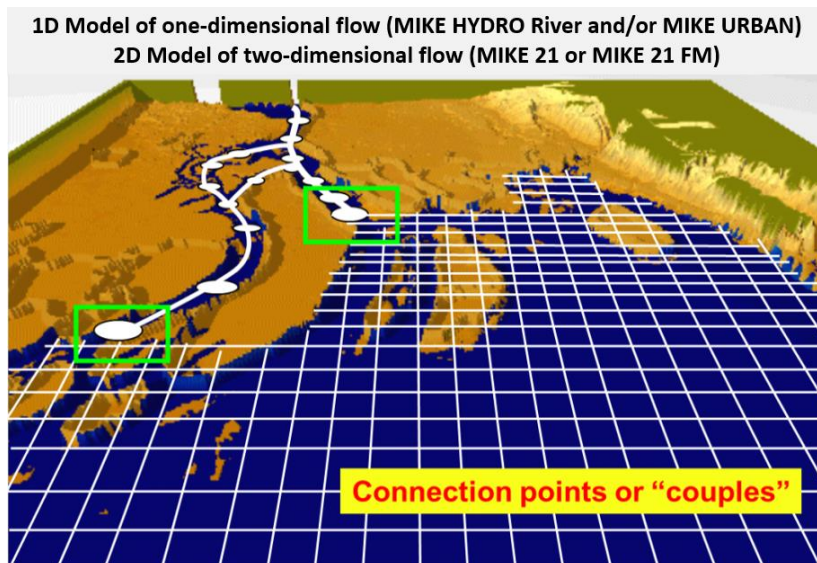


Figure 3.5 Coupling of MIKE HYDRO River and MIKE 21 Flow Model FM through MIKE FLOOD (DHI, 2016a)

For this modelling study, the coupling of the MIKE HYDRO River and MIKE 21 Flow Model FM model is made through lateral linkage options provided in MIKE FLOOD. Schematisation of lateral links is illustrated in Figure 3.6.

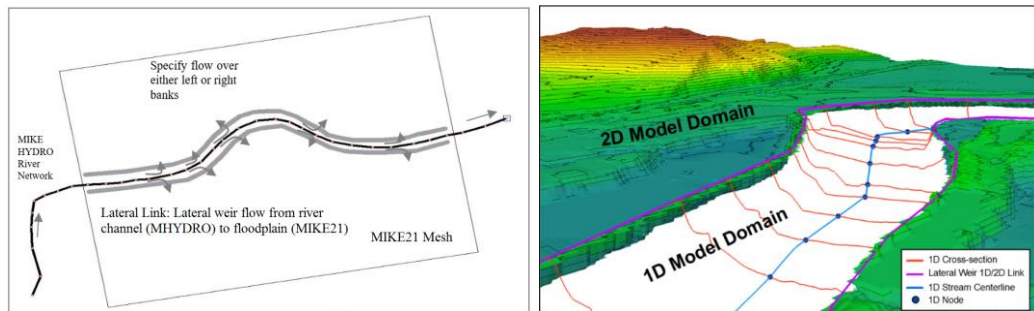


Figure 3.6 Lateral linkage option in MIKE FLOOD (DHI, 2016b).

The main inputs needed for the coupled 1D-2D coupled model are bathymetry, rainfall, tide, and structures. Data gathering and pre-processing for these model inputs are described in the next sections.

In the trainings that have been done, these are the topics that has been explained to the training participant:

- a) MIKE FLOOD concept
- b) Setting up the couple model with MIKE FLOOD
- c) Presenting simulation results

During this training, participant already used the actual Jakarta data that have been gathered. Participant also did some hands on after trainer gave some explanation.

This page is intentionally left blank

4 References

BAPPENAS, (2010): *ICCSR – Scientific basis analysis and projection of sea level rise and extreme weather events*. Indonesia.

Budiyono, Aerts, J., Tollenaar, D., Ward, P., (2016): *River flood risk in Jakarta under scenarios of future change*, *Nat Hazard Earth Syst. Sci.*, 16, 757-744, doi: 10.5194/nhess-16-757-2016

DHI, (2016a): *Introduction to MIKE FLOOD: Integrated 1D-2D Flood Modelling for Urban, Riverine and Coastal Flooding*, presented in BPPT training, 11 October, South Tangerang, Indonesia.

DHI, (2016b): *MIKE FLOOD User Manual*, Hørsholm, Denmark.

DHI, (2017): *Hydrodynamic modelling for flood reduction and climate resilient infrastructure development pathways in Jakarta - Hydrodynamic Flood Modelling Report*, Jakarta, Indonesia.

Google earth pro V 6.2.2.6613, SIO, NOAA, U.S. Navy, NGA, GEBCO, TerraMetrics 2012, DigitalGlobe 2012. <http://www.earth.google.com>.

Sopaheluwakan, J., (2017): *Blue Green Jakarta 2030, Keynote Overview on Hydrodynamic Modeling and Social Economic Changes in Kapuk Polder System*, presented in Workshop: "Menuju Jakarta Berketahanan Iklim : Pemodelan Hidrodinamika untuk Penyusunan Tuntunan Pembangunan Infrastruktur Pengurangan Bencana Banjir dan Berketahanan Iklim di Jakarta", 21 April, Jakarta, Indonesia.

Van der Sleen, N and Lopez, J., (2013): *An analysis of the Pluit polder*, Jakarta, Bachelor thesis, Universitet Twente, Netherland.

This page is intentionally left blank