Netherlands Commission for
Environmental Assessment

Advice on Scoping Report for EIA for the Pan Hlaing Sluice Project

MYANMAR

30 March 2017
Ref: 7215

Advisory Report by the NCEA

Subject	**Advice on Scoping Report for EIA for the Pan Hlaing Sluice Project**
To	Mr U Kyaw Myint Hlaing Ministry of Agriculture, Livestock and Irrigation (MoALI) – Myanmar
From	the Netherlands Commission for Environmental Assessment (NCEA)
Technical secretary Quality control	Mr Arend Kolhoff Ms Bobbi Schijf
Experts consulted	Mr Gert Jan Akkerman Mr Rudy Rabbinge (Chair)
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Netherlands Commission for
Environmental Assessment

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Our reference: 7215/KH/LW
Enquiries to: Arend Kolhoff
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Date: 30 March 2017
Subject: ESIA Pan Hlaing Sluice

Dear Mr U Kyaw Myint Hlaing,

In your letter dated 12 December 2016, you requested the Netherlands Commission for Environmental Assessment to prepare an advice on the scoping document for the Environmental and Social Impact Assessment for the Pan Hlaing Sluice Project.

It is my pleasure to submit herewith the final "Advice on Scoping Report for EIA for the Pan Hlaing Sluice Project".

I would like to draw your attention to the following points:

- The proposed project aims to achieve the following three objectives: Seasonal fresh water reservoir to use the water for agricultural, domestic and industrial purpose; mitigation of salt intrusion and sedimentation, and rainstorm flood control. The NCEA has assessed the project and suggests to include the following four additional functions:

  - a storm surge barrier function to cope with cyclone flood risk;
  - navigation passage function so ships can continue to use the Pan Hlaing River;
  - energy generation by making use of flow turbines;
  - use of the sluice as a bridge to cross the sluice for light transport such as pedestrians.

  These functions can most likely be added to the main functions of the sluice without difficulty and it is likely that the societal benefits outweigh the costs. It would be beneficial to include a comparative cost benefit analysis of the original project and the suggested extended project in the EIA.

- The NCEA noted that the main objective of the project, the creating of a temporary freshwater reservoir for agricultural, domestic and industrial purposes cannot be achieved

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when the drainage of untreated poisonous industrial waste water is not adequately addressed. I strongly suggest to start working on a good practice solution of this problem.

- The NCEA noted that there is a lack of knowledge and information. I recommend to start a measuring campaign starting this March and continuing in April to have a reference of the dry period.

- At this moment, the following studies still have to be carried out: detailed design study, EIA study, economic feasibility study and financial feasibility study. The NCEA recommends to align the first three studies as they can benefit from each other and that might result in better quality studies and it safes time. I suggest to make use of international experts, with experience in EIA for complex projects.

The NCEA is ready to review the draft final EIA and is more than willing to carry out this review jointly with MoNREC, who are formerly responsible for this review.

Yours sincerely,

Prof. Rudy Rabbinge PhD, MSc, FRS
Chairman of the Working Group

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1. Introduction

1.1 Project initiative

The Pan Hlaing Sluice Project is initiated, and will be owned by, the Myanmar Ministry of Agriculture, Livestock and Irrigation (MoALI). This project is part of the Memorandum of Understanding between the Government of Myanmar and the Government of the Netherlands to collaborate on water challenges, partly as a learning-by-doing project.

This project is known as the Pan Hlaing Sluice Project, located west of Yangon in the Pan Hlaing River. The Pan Hlaing River connects the Ayeyarwady River to the east (which provides inflow of fresh water) and the Yangon river to the west (which provides inflow of saline water due to the tidal influence) see figure 1. The project's aim is to construct a multi-functional sluice in the Pan Hlaing River, to achieve the following objectives:

- Fresh water reservoir function: The Pan Hliang River will become a seasonal fresh water reservoir that will provide additional water to supply 50.000 hectares of agricultural land during the dry period. The reservoir will also provide freshwater for domestic use for future extension of the residential area of Yangon and fresh water use by industries adjacent to the Pan Hlaing River;
- Mitigation of salt intrusion and sedimentation from the Yangon River towards the Pan Hlaing River;
- Flood control function: Improving rainstorm flood control by arresting high tides from the Yangon River, whilst at the same time allowing for sufficient drainage.

The operation of the sluice will be highly dynamic and is complex because of the combinations of different functions. See figure 2 for a sketch impression of the proposed Pan Hlaing Sluice project. The 'sluice' functions rather like a **tidal barrier** and hence we would recommend to rename the Pan Hlaing Sluice as the Pan Hlaing Tidal Barrier. In the following, in order to be consistent with the studies carried out thus far, we will still refer to the structure as the Pan Hlaing Sluice.

The Pan Hlaing Sluice project is the last phase of the rehabilitation of the Pan Hlaing River. In the last decades, almost the entire Pan Hlaing river had silted up. MoALI intended to rehabilitate this river and in 2014-2015 they constructed the Mezali sluice 2 and dredged the river. With the execution of the proposed Pan Hlaing sluice project, the rehabilitation of the Pan Hlaing River is completed and siltation is expected to be under control.

Objective of this advisory report

By letter dated 12 December 2016, the Netherlands Commission for Environmental Assessment (NCEA) has been asked by the MoALI to (i) prepare an advisory report for the scoping stage for the Environmental and Social Impact Assessment study (EISA)[1] for the Pan Hlaing Sluice project and (ii) to involve the staff of MoALI in this process in order for them to be exposed to the approach of the NCEA in preparing a scoping advice for EIA (Annex 1).

[1] The NCEA uses the term Environmental and Social Impact Assessment (EIA) in this advisory report because the IFC performance standards require to include social aspects and use this term. The Myanmar Environmental Impact assessment procedure, also provides requirements to execute a Social Impact Assessment as part of the EIA.

The main purpose of this advisory report is to provide an advice for the process and the contents of the EIA study and report that are needed for the Pan Hlaing Sluice Project.

Figure 1: Plan view of Pan Hlaing River (the river section that is directly related to the Project is shown in green) in between the Ayeyarwady River and the Yangon River.

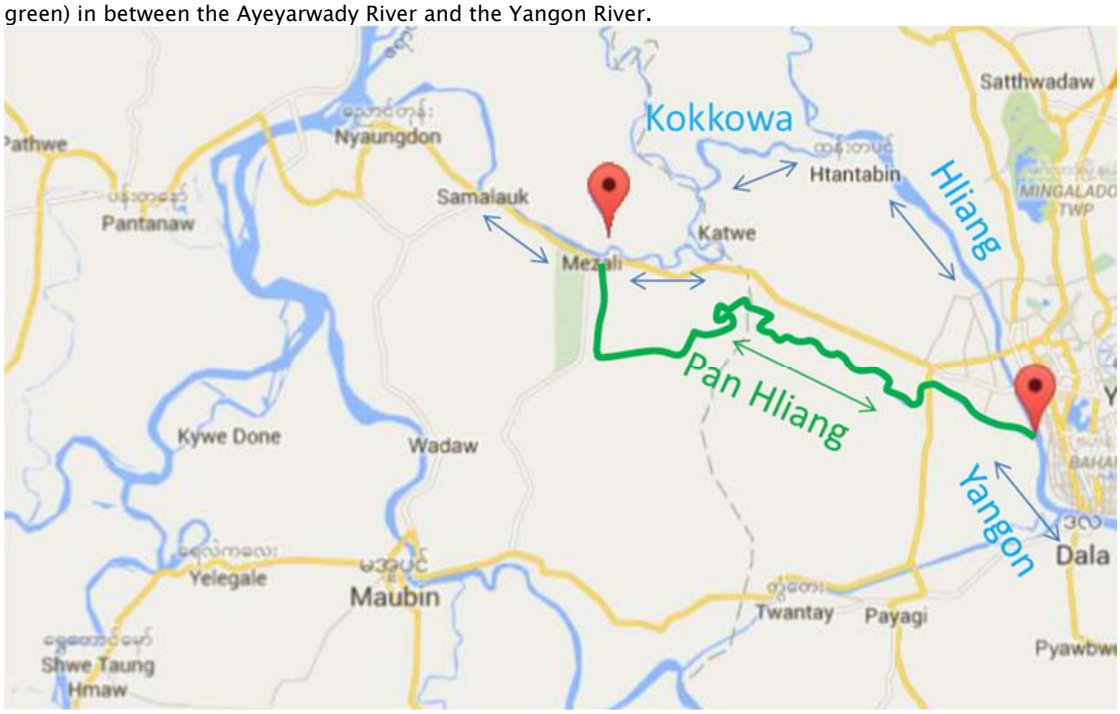
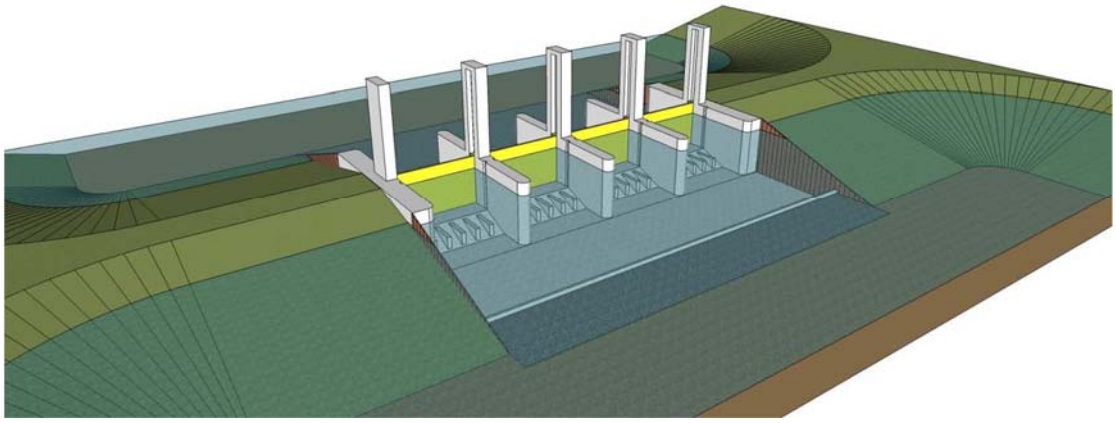


Figure 2: A sketch impression of Pan Hlaing Sluice looking towards the Pan Hlaing River. Source: Final Feasibility Study Pan Hlaing Sluice, Myanmar, 8 April 2016):



1.2 Approach by the NCEA

Expert working group

This advisory report has been prepared by a working group of experts of the NCEA which consists of the following three experts:

- Dr Arend Kolhoff, Technical Secretary of NCEA and EIA and environmental expert;
- Mr Gert Jan Akkerman MSc, River and coastal expert;
- Prof Rudy Rabbinge, Chair and agricultural expert.

The Dutch Ministry of Foreign Affairs has funded the preparation of this advisory report under a multi-annual agreement with the NCEA to provide such services in a selected number of countries, including Myanmar.

Justification of the approach

The NCEA has studied the following documents to prepare this advisory report. In Annex 4 the appraisal of these documents is presented. A consortium of Royal HaskoningDHV (lead partner), Deltares, Delft University of Technology and BPS has prepared these reports.

- (1) PHRIDP report: Pan Hlaing River Integrated Development Plan (30 October 2015):
  This report focuses on the integrated development of the project: the project approach, data analysis, stakeholder analysis, the natural delta system, hydrodynamic modelling, agriculture and irrigation demands, factsheets and the sluice design within integrated development planning.
- (2) Final Feasibility Study Pan Hlaing Sluice, Myanmar (8 April 2016):
  This report elaborates further on the sluice design, the relation with industrial wastewater discharged in the river, construction phasing and indicative cost estimation. The report leads to a design (sketch level) of Pan Hlaing Sluice. A major conclusion of the Feasibility Study is that the construction of the sluice is feasible and would undoubtedly contribute to the objectives set.
- (3) Sketch Design Pan Hlaing Sluice, Myanmar (7 April 2016):
  This report is distilled from report (2) and is only focusing on the sketch design of the sluice (which was also dealt with in report (2), but was less systematically reported). Hence, for our advice we refer to reports (1) and (2).

It should be mentioned that the reports that have been studied only covered the design stages up to the development of a sketch design of the Pan Hlaing Sluice. The EIA is based on this sketch design and provides input to the detailed design study, as well as guidance on the operation & maintenance management plan, which is still to be developed.

For the preparation of this advisory report two members of the working group (Mr Kolhoff and Mr Akkerman) visited Myanmar from the 16th until the 21st of January 2017. On the 19th of January 2017, a one-day field visit was made to the project area of the Pan Hlaing Sluice project, guided by representatives of MoALI, as well as of the Netherlands Embassy. This field visit included a boat trip from the temporary dam site (knows as coffer dam) towards the river mouth of Pan Hlaing River, as well as a tour by car via the industrial area situated north of the river towards the Pan Hlaing Bridge. Subsequently, the visit proceeded upstream, during which typical irrigated lands and water control infrastructure were shown. At the most upstream point, near the bifurcation with the Kokkowa river, the recently constructed Mezali

Sluice 2 was visited. The observations made during the field visit are briefly reported in Annex 3.

Preceding the field visit, a meeting was arranged on the 17th of January 2017 with the Director General of MoAI, followed by an in-depth meeting with high-level staff from the Ministry, under the leadership of Director Zaw Lwin Tun. At the end of the mission, in the morning of Friday the 20th of January, a wrap-up meeting was arranged with the Chief Minister of the Yangon Regional Government and his direct staff, as well as with Director Zaw Lwin Tun and representatives of the Netherlands Embassy.

On the 6th of March 2017, a draft of this advisory report was discussed with representatives of the Dutch Government in the Netherlands. The draft of this report was also discussed with staff of MoALI on the 14th of March 2017 and with a staff member of the Netherlands embassy in Yangon on the 16th of March 2017.

At the request of MoALI, the following two regulations will be used as a reference framework for this EIA scoping advice:

- The Government of Myanmar requirements for EIA, as explained in the EIA procedure adopted in January 2016. According to the criteria of economic activities requiring IEE or EIA, the proposed Pan Hlaing Sluice Project meets at least two criteria for EIA, see table 1, No. 111 and 115. Whether the project also meets criterion No.113 depends on the decision to include one additional function to the project, which can be explored as an alternative function to the project. This alternative function is elaborated by the NCEA in Chapter 6.
    - No. 111. The height of the sluice that actually functions as a dam is less than15 meters but the reservoir area is more than 400 ha. An EIA is required based upon the size of the reservoir, which will be larger than 400 ha.
    - No. 113. Other large civil works: Strengthening of the embankments of the Pan Hliang river over a length of more than 2km could become part of the project. This criterion might be valid when the NCEA's suggestion to assess the storm water surge barrier function will be included in the project.
    - No. 115 River channel conservation (surface water & water volume control), all sizes. An EIA is required as the project meets this criterion as a large water volume will be controlled as a result of the barrier.
- The IFC performance standards: application of these standards is a requirement of funding agencies such as the Netherlands Enterprise Agency (RVO). The NCEA first determined which IFC performance standards are relevant for this project; see Annex 2 for the findings. Secondly, guidance has been included in this advisory report concerning the performance standards likely to be triggered. Following the guidelines of the IFC, the NCEA makes use of the ecosystem services approach. This approach is elaborated by the UN Millennium Ecosystem Assessment (2003)[2].

For the structure of the Chapters 3 to 10 in this advisory report, the NCEA follows the topics of the "Scoping report for EIA", as prescribed by the EIA procedure (MoNREC, January 2016).

[2] Millennium Ecosystem Assessment (2003) Ecosystems and human Well-being: A framework for Assessment. Island Press. http://www.millenniumassessment.org/en/products.aspx).

Table 1: Type of economic activity applicable for the Pan Hlaing Sluice project.

No. Type of economic activity	Criteria for IEE type economic activities	Criteria for EIA type economic activities
111. Dams and Reservoirs	Dam height < 15 m and Reservoir area < 400 ha	Dam height ≥ 15 m or Reservoir area ≥ 400 ha
113. Other Large Civil Works Construction (embankments, seawalls, offshore break-water)	Length < 2 km and area < 25 ha	Length ≥ 2 km or Area ≥ 25 h
115. River Channel Conservation (surface water & water volume control)		All sizes

Reading guide

Not all parties involved in this project have extensive experience with EIA. Therefore, the NCEA has provided a short explanation of the purpose of each of the aspects of EIA addressed in the Chapters 4 to 8 *in italics* under the heading of these chapters.

For the structure of the Chapters 4 to 10 the NCEA follows the contents for the scoping report as requested by the Myanmar EIA procedure (adopted January 2016). In most of these chapters, we follow a two-step approach. First, an assessment is made to determine what information is available in existing reports. Then, if the information turns out to be incomplete or unclear, an explanation will be given as to why this information is important and needs to become available in the EIA process. Secondly, specific recommendations will be included to guide the EIA study.

In Chapter 3, recommendations are provided for the EIA *process*. In the Chapter 4 to 11 recommendations are provided for the *content* of the scoping report and EIA study.

2. Guidelines for the EIA process

2.1 From an advice to the Scoping report

The NCEA would like to acknowledge that this report is an advice for a scoping report. Scoping is a critical, early step in the preparation of an EIA study and report. The scoping process identifies the issues that are likely to be of most importance during the EIA and eliminates those that are of little concern. In this way, scoping ensures that EIA studies are focused on the significant effects and time and money are not wasted on unnecessary investigations. The involvement of the public, as well as the competent authority and other responsible government agencies, is an integral part of the scoping process. Public input helps to ensure that important issues are not overlooked when preparing Terms of Reference and/or initiating the EIA study. The purpose of scoping is to identify:

- the important issues to be considered in an EIA;
- the appropriate time and space boundaries of the EIA study;
- the information necessary for decision-making;
- the feasible alternatives to a proposed action; and
- significant effects and factors to be studied in detail.

MoALI is the proponent and according to the Myanmar EIA procedure responsible for the preparation of the scoping report. In this advice the NCEA has provided guidelines for this scoping report but not all requirements for a scoping report are elaborated at the same level of detail. In this advice the NCEA has provided detailed guidelines on problem analysis, project description and alternatives, for the other issues guidelines have been prepared but they still need to be further elaborated and / or or executed.

The NCEA recommends:

- to elaborate in the Scoping report in more detail the following issues: policy, legal and institutional framework, description of the environment; key potential environmental impacts;
- to conduct as part of the scoping the public consultation and participation process as requested by the Myanmar EIA procedure and as requested by IFC Performance standards.
- to elaborate gaps in knowledge and information, and the environmental management plan in the EIA study instead of in the Scoping report.

2.2 Alignment and integration of EIA with other studies

The NCEA would like to note that good practice has shown that the effectiveness of EIA is greatly dependent on how well the EIA can be aligned with other assessment work, and integrated into decisions on feasibility, design and approval of the project. Therefore, we are making a number of recommendations on alignment and integration in this chapter.

In the preparation of the Pan Hlaing Sluice project three studies, as mentioned in Chapter 2, have already been executed. And the following four studies still need to be carried out:

- Detailed design study;
- EIA study;
- Economic feasibility study;

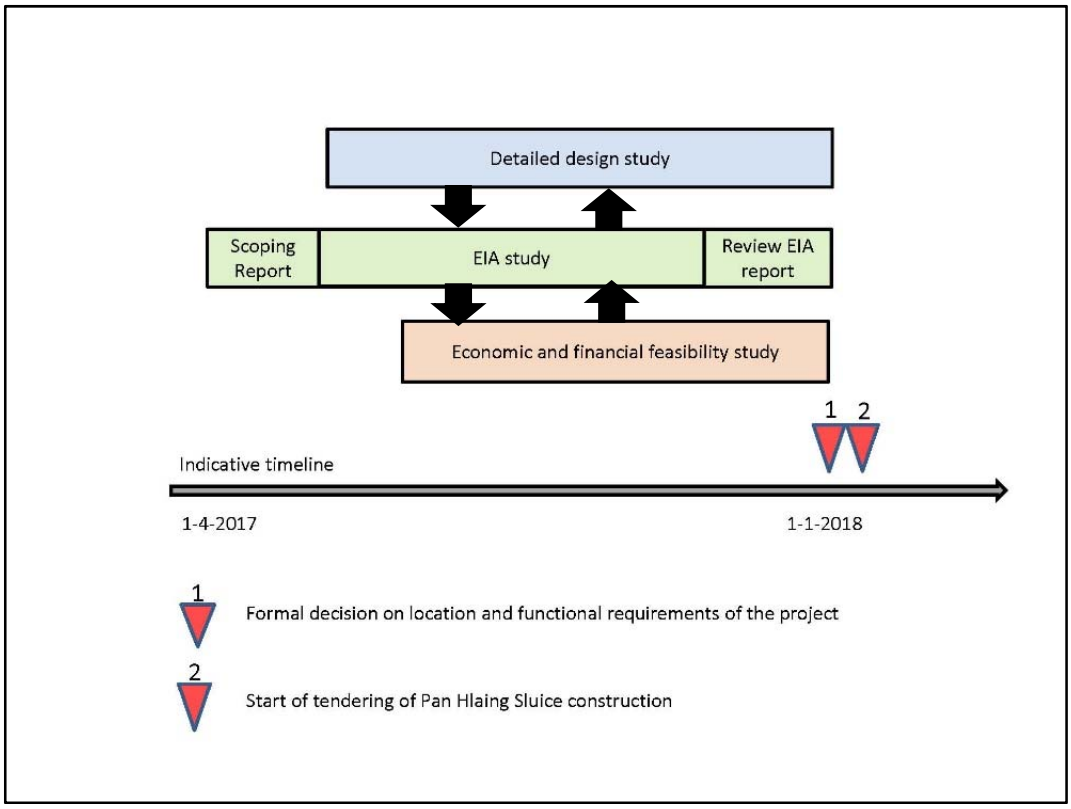
- Financial feasibility study.

The NCEA recommends:

- to align the first three studies as they can benefit from each other, potentially resulting in better quality of the studies and time savings;
- the detailed design study can optimally benefit from the EIA study when they are developed in parallel and the experts involve in both work closely together;
- MoALI has indicated that they want to execute and fund the EIA themselves with support of Myanmar experts / consultants. Due to the complexity of the project, it is recommended that for the development of the EIA, international expertise is mobilized, particularly expert(s) with extensive experience in EIAs for complex projects and with international EIA benchmarks such as the IFC Performance Standards;
- the need to justify in the economic feasibility study, the economic feasibility in terms of positive societal benefits over the societal costs. The cost-benefit analysis included, should compare the situation with and without the project. Predominantly, this should be done in a quantitative way. The EIA study can provide the necessary input for the economic feasibility study.

The indicative process diagram below illustrates the interaction of the various activities.

Figure 3. Indicative illustration of the various process interactions.



3. Context of the project

At the start of an EIA process there should be a clear analysis of the problem that the project is intended to solve, and a set of project objectives that the proposed activity, and any alternatives, should meet. The scoping stage can be used to refine the project context, the problem analysis, and the project objectives, so that these can be set out in the scoping document.

3.1 Problem analysis

In paragraph 3.1 we consider the morphodynamic situation before 2014 as well as the existing situation.

Morphodynamic situation (before 2014)
The major problem encountered within the Pan Hlaing River a few years ago was severe sedimentation, especially in the mid-reaches. As a result the river was actually blocked during lower flows. The sedimentation amounted to several meters and led to, for instance, floodplain occupation and road construction at the blocked areas. As no structures were present at that time which could be blocking the flow, the siltation must have had causes other than direct interference by people. Likely, the increased silt content in the Ayeyarwady River has contributed to this siltation. As a result, low flows could not pass downstream whereas high flow capacity was restricted.

The siltation was very detrimental to the fresh water availability during the dry period and this had serious adverse effects for irrigation. In the wet period, the rainstorm drainage capacity was reduced by the restricted outflow capacity of the Pan Hlaing River towards the Yangon River, which led to increased rainstorm flooding in the riverine areas.

Current morphodynamic situation
To relieve the abovementioned problems, in 2014 an extensive dredging programme was carried out. The main channel was dredged so that sufficient depth and cross-sectional area of the main channel were obtained. Subsequently two additional measures were taken:

1) Construction of a temporary sand dam (indicated as the 'cofferdam') in the downstream reach near the river mouth. The cofferdam is said to be closed during the dry season to avoid salt water intrusion and prevent the highly silt-laden water from entering the Pan Hlaing River. The cofferdam was closed during the previous dry period. However it has been opened since (during the present dry period). Unfortunately, no systematic water quality monitoring was done during the closure period, nor during other periods.
2) Construction of an upstream sluice near the bifurcation with the Kokkowa River (Mezali Sluice 2). The Mezali Sluice 2 is a flow regulation sluice.

The NCEA noted that in-depth understanding of the morphodynamic situation (current situation as well as the situation before 2014) seems to be lacking. This is also reflected in the fact that, as far as we know, no systematic measurement campaigns have been carried out on sediment, water flows and water quality.

The NCEA notes that there might be a considerable risk that the Pan Hlaing River will be silted up again before the Pan Hlaing Sluice has become operational. In addition, the hydrody-

namic and morphodynamic effect of the Mezali Sluice 2 is unclear at this moment, partly due to the lack of information regarding the operational usage of the Mezali Sluice 2. A practical question now is to what degree it is useful to restart temporarily closure of the cofferdam in the dry period, while the Pan Hlaing Sluice is not yet operational.

In short, we note that the problems of some years ago are quite clear and obvious. However, the current hydrodynamic situation (with a dredged channel, with a cofferdam installed and re-opened again and an upstream inflow regulating Mezali sluice 2) is not sufficiently known.

The NCEA recommends:

- to better investigate the current problems: a) in order to have a better understanding and b) to be able to advise on how to best handle the current situation in the coming time, while the Pan Hlaing Sluice is not yet implemented. In the view of the NCEA team, this intermediate stage should also be part of an integrated design approach. Hence, we advise to include in the EIA a proper baseline study, as far as is possible against the background of absence of systematic measurement data (we acknowledge that a measurement campaign may logistically be impossible in the short-term);
- to explicitly include the anticipated effect of the Mezali Sluice 2 in this problem analysis;
- to assess whether it is useful to restart temporarily closure of the cofferdam in the dry period while the Pan Hlaing Sluice will not yet be operational.

Major questions to be answered:

- To what extent has re-sedimentation occurred along the Pan Hlaing River (this follows from comparison of the after-dredging situation and a simple bathymetric echo-sounder survey of the present bed level)? We would remark here that from a longitudinal sedimentation profile, the influence of salt intrusion on the sedimentation may be indicated; this may give an indication on the need to re-close the temporary cofferdam during the coming dry season.
- What is the present operational strategy of the Mezali Sluice 2?
- What were the circumstances (time frame during the dry season, water levels) at which the temporary cofferdam was closed and re-opened?
- What was the indicative effect on dry season water levels during closure of the cofferdam? (In case of lack of measured data, refer to observations, such as approximate water level upon closure of the cofferdam, availability of water at the end of the dry season and corresponding water levels.)
- In how far has rainstorm flooding been mitigated after dredging; can anything be said about the influence of the Mezali Sluice 2 on this mitigation?
- To make an analysis that provides insight in the factors (e.g. water, labour, inputs etc.) that are presently hampering the agricultural use in the dry season and the relative importance of fresh water.

The underlying question to be addressed is not how the Pan Hlaing Sluice would solve the problems of some years ago, but to anticipate how it will perform in the situation at and after completion of the sluice.

3.2 Objectives

The following three objectives have been identified for the project by MoALI:

- To development of a seasonal fresh water reservoir to use the water for irrigation, domestic and industrial purposes.
- To sustain the fresh water function, salt-water intrusion and sedimentation need to be mitigated, which also favours the drainage function (to mitigate rainstorm flooding).
- To improving rainstorm flood control by arresting high tides from the Yangon River, whilst at the same time allowing for sufficient drainage.

These objectives are briefly elaborated in this section, but need to be described and justified more extensively in the EIA.

Fresh water reservoir function

The main project objective is to create a fresh water reservoir that can be used for (supplementary) irrigation of about 50.000 hectares, to provide domestic water for about 2 million people and to providing water for industrial use for which no quantities are indicated. At this moment, three locations are being considered for the construction of the Pan Hlaing Sluice project and they differ in the degree to which these three targets can be achieved. Because the size of the reservoir and the access to the reservoir is influenced by the location of the sluice. To sustain a basic ecological function and a habitat for fish, a minimum amount of water needs to remain in the reservoir.

The NCEA recommends:

- To justify that the amount of freshwater that can be stored is sufficient for supplementary irrigation of 50.000 hectare and for domestic use by 2M people and for use by industry, to be specified for each month;
- To justify the minimum amount of water in the reservoir to sustain the basic ecological function and habitat for fish.

Mitigation of river re-sedimentation and salt water intrusion

To maintain the reservoir function of the Pan Hlaing River and to ensure the reservoir can be used as a fresh water reservoir, the Pan Hlaing Sluice needs to prevent or at least mitigate re-sedimentation and salt intrusion.

The NCEA recommends:

- to justify in the EIA how the siltation and salt intrusion will be mitigated through the proposed project. The operational management of sedimentation by the Mezali Sluice 2 also needs to be taken into consideration;
- to describe for the years the Pan Hlaing Sluice project is not yet operational, how the replacement / closure of the cofferdam can mitigate salt intrusion and sedimentation in the dry period.

Flood control function

Better control of water levels during the wet season has been identified as another major objective or function, in order to prevent or at least mitigate flooding from heavy rainstorms.

The NCEA briefly explains her understanding of this function as it has not yet been elaborated in the aforementioned studies. The Pan Hlaing Sluice will not improve the *drainage capaci-*

ty from the Pan Hlaing River towards the Yangon River, as it will always pose some restriction by its presence, even when the gates are fully opened. The essence here is that the water levels in the Pan Hlaing River can principally be kept at a lower level by blocking-off the higher tidal levels from Yangon River by active closure of the gates during the higher tidal periods (twice a day). In essence, the Pan Hlaing Sluice will thus actually function as a tidal barrier. Drainage from the riverine areas will be favoured with the water levels in the river kept at a lower level. However, the total discharge should still be drained via the river towards the Yangon River, so the gates need re-opening as soon as possible to allow for outflow. Moreover, the cross-sectional area of the gates should be large enough. The indicative simulations in the PHRIDP study show that this capacity is sufficient, in combination with blocking off the peak water levels, to lower the water level near the mouth by more than 1 meter.

The NCEA recommends:

- to describe in the EIA to what extent the design criteria and operational management of Pan Hlaing Sluice Project can contribute to (i) controlling water levels during the wet season and (ii) the drainage capacity.

Other useful functions

Other useful functions have not been mentioned in the previous studies. During the visit to Myanmar the NCEA has suggested and discussed three additional functions for the Pan Hlaing Sluice Project with Dr Zaw of the MoALI. Dr Zaw has asked the NCEA to include these functions in our advisory report (see chapter 4.1) so that they can be further elaborated in the EIA.

4. Policy, legal and institutional framework

During scoping the policies and regulations that are relevant for the project need to identified, and any implications for the project determined. This is necessary to check if the intended initiative fits within these policies and regulations, but also to determine any environmental and social performance standards that the project needs to comply with. This exploration can include any requirements that have been set by relevant financing institutions.

The NCEA noticed that the following important policies and laws might influence the project:

- The strategy of agricultural development of Myanmar and in particular what are the plans for the 50.000ha irrigated command area that will benefit from the fresh water that will become available as a result of the project.
- East-Yangon city development plans for the area south of the Pan Hlaing River that is intended to be developed as a residential area.
- Plans or policies for domestic water supply of the above mentioned residential area extension.
- Plans for the extension of the industries and industrial zone north of the Pan Hlaing River. In particular, to what extent present and future industries will use the Pan Hlaing River for transport.
- Plans for the improvement of environmental performance of the industries in the zone north of the Pan Hlaing River.
- Plans on the use of the main rivers for navigation purposes, in particular the proposed plan to improve the navigability of the Twante canal e.g. by constructing a sluice.

The NCEA recommends:

- to elaborate these (and possible other relevant) policies briefly in the EIA report and describe how they influence the proposed project;
- that the project and identified (project design and location) alternatives are checked for their consistency with the relevant existing policies and plans. Such a consistency check provides insight in the way the proposed project / alternatives are contributing towards the achievement of objectives in the approved plans and policies. If it turns out that project activities are in conflict with one of the plans or policies, the EIA study should describe how this can be resolved.

5. Project description and alternatives

Each of the project activities needs to be described, to enable the assessment of the environmental and social effects. The purpose of developing alternatives is to identify and investigate any potential alternatives that may promote more environmentally sustainable, socially acceptable and economically feasible solutions.

5.1 Project description

The proposed project is related to one specific structure, i.e. the Pan Hlaing Sluice, for which the location still needs to be selected. The full-potential functionality, in relation to the recently constructed upstream flow regulation sluice (Mezali Sluice 2) and the Yangon River levels, as well as the influence on the upstream Pan Hlaing River and Kokkowa River has not been considered yet in the three available studies. The NCEA observes that the major focus of the PHRIDP study (Report 1) and the feasibility study (Report 2) is the location of the Pan Hlaing Sluice, rather than the full extent of services that the sluice could offer. The NCEA recognizes that the location has a large influence on the functionality and the feasibility of the various functions and this is a major variable to decide upon indeed. Nevertheless, the NCEA is of the opinion that the functionality of the sluice, acting together with the upstream Mezali Sluice 2, has not fully been explored (at least: this was not properly described in the reports). We would point out that the two sluices have different functionalities: Mezali Sluice 2 is really a flow regulator (so a real sluice), whereas Pan Hlaing Sluice is a tidal barrier and hence a water level regulator. How both interact, when compared to the earlier baseline (without Mezali Sluice 2 and before dredging) and the current baseline (with Mezali Sluice 2 and after dredging) has not been made clear.

Another remark is that the feasibility study focused on a schematized dry season situation as well as a schematized wet season situation (August 2012). However, transitional seasons have not been considered, nor the natural variability within dry and wet seasons. Such transitional seasons can be of the utmost importance, e.g. to ensure that the reservoir function is optimally met (which includes timely filling at the end of the wet season, however at the risk of rainstorm flooding). We acknowledge that the lack of data is the major reason of the above lacuna. However, such detailed performance, closely related to the detailed sluice design and operation, does need to be explored further in the detailed design study.

The NCEA recommends to study in the EIA:

- reconnaissance of the full potential functionality and feasible operation strategies in relation to the usage of Mezali Sluice 2;
- the functionality for daily operations to be demonstrated for a wide set of scenarios (e.g. inter-seasonal, coherence with Mezali Sluice 2 operations, wide variety of boundary conditions);
- the functionality to be investigated in anticipation of extreme scenario operations, e.g: extreme rainfall, extreme drought, extreme bad water quality response, sediment flushing scenarios, hurricane approach, etcetera.

As a result, the EIA will give insight in the functional robustness of the Pan Hlaing Sluice and will give operational requirements which will have to be translated into the final design (e.g. speed of gate operations, emergency procedures, information and decision support requirements).

5.2 Suggestions for additional functions

As noted above, the proposed Pan Hlaing Sluice Project aims to fulfil the following three main functions or objectives: (i) a fresh water reservoir (ii) mitigating salt-water intrusion and sedimentation and (iii) flood water control. In addition, as stated in the feasibility study, the sluice can become a landmark. During the field visit, the NCEA noticed that the project could contribute to achieve the following four additional functions or objectives as well. Considering these functions might lead to a more sustainable, a more adaptive and a more widely accepted project. These functions are:

- storm surge barrier to cope with cyclone flood risk;
- navigation passage function;
- energy generation function;
- bridge to cross the Pan Hlaing River.

These functions are briefly explained below.

Storm Surge Barrier function to cope with cyclone flood risk

Special reference is made here to cyclone Nargis that caused enormous devastation along the Ayeyarwady Delta with at least 138,000 direct fatalities in May 2008. Although the majority of fatalities have been reported in the seaward Delta (e.g. Labutta, Bogale), the NCEA was told during the field visit that the riverine area of Pan Hlaing River was also severely affected.

The presence of Pan Hlaing Sluice, when placed in the mouth of the Pan Hlaing River, provides an opportunity to secure the hinterland from being flooded again when a new cyclone would make landfall in Myanmar. This function is additional to the main flood mitigation function that has been identified in the PHRIDP study, i.e. improvement of drainage and hence mitigation of rainstorm flooding during the wet season. Such rainstorm flooding is quite common, so mitigation is very important for daily life during the wet season. However, the aftermath of a heavy cyclone can be much more destructive, as it may cause massive and almost instantaneous flooding with the risk of a high number of fatalities.

The idea is to block off the incoming strong surges (commonly, several surges will occur during one storm event), associated with the approach of the cyclone, by briefly closing the gates. This will be at the cost of increased rainstorm flooding, as the drainage function will be hampered during that period and most likely drainage is critical too due to the excessive rainfall by the cyclone. However, immediately after recession of the storm surge(s), the gates can be opened again to resume the drainage function.

Obviously, the adjoining abutment banks, as well as the river banks along the Hlaing River and Yangon River may have to be raised. During the field visit, it appeared that the northern banks of Pan Hlaing River, as well as the banks along Hlaing River, near the planned site of the sluice, have already been reinforced. This has been done in anticipation of the Pan Hlaing Golf Estate extensions. In addition, more river-bank sections will have to be reinforced east of the Pan Hlaing Sluice in order to protect the hinterland against cyclones. When the Pan Hlaing Sluice would be functionally 'cyclone proof' such reinforcements can subsequently be done in future. This will avoid future raising of the river banks all along the Pan Hlaing River.

The NCEA recommends elaborating the Storm Surge Barrier function in the EIA, but only for the location in the mouth of the river (Location 1 in the sketch design). In the view of the NCEA, this function is not feasible for the other two locations of the sluice that have been identified. To make a storm surge barrier effective the river banks have to be raised and that needs to be elaborated in the EIA as part of the project.

Navigation passage function

A negative impact of the Pan Hlaing Sluice is that the proposed design of the sluice effectively blocks the present navigation in between the Yangon River and the Pan Hlaing River. Before the start of the drafting of this advisory report MoALI was of the opinion that this might have to be accepted, as the additional costs for a shipping lock are inhibitive.

During the visit, the NCEA noticed that the Pan Hlaing River is more intensively used for transport than was expected based upon information provided in the Feasibility study (report 2). Therefore, the NCEA suggest to reconsider the passage function of the sluice We have suggested two options to explore further: a natural passage and a navigation lock. The pros and cons of these two options need to be elaborated in the EIA for the three identified locations.

Option 1: 'Natural' passage

The strong daily semi-diurnal tides at the Yangon River allow for natural passage during brief time intervals at slack tide via the Pan Hlaing Sluice, if the gates (or one of the gates) can be raised high enough to allow ships a safe passage underneath the gate(s).

The basic function of the Pan Hlaing Sluice is to keep the salt water from the Yangon River out of the Pan Hlaing River. To this end, the gates will be closed twice a day during upcoming tide. In the remaining periods, the gates will mainly be open during the wet season or mainly closed during the dry season, or dynamically operated for transitional seasons. There are four brief periods of slack tide a day in which the water level on both sides of the Pan Hlaing Sluice balance. During these periods navigation would be possible without using a shipping lock. During the slack-tide period of the upcoming tide, salt water may intrude. Hence from a water management point-of-view it seems more obvious to utilize the two outgoing tidal slack-water periods only, as this will reduce salt water intrusion. To reduce water losses, however in the dry season the two incoming slack tides may have to be used. This should be studied in detail if this option were to be selected.

Utilizing such 'natural' passage during the slack water periods, for which water level differences will be small, will require, amongst others, special gate design (quick response gates that can be raised high) and very precise operations and intensive navigation guidance. Moreover, the passage will be limited to two or four brief periods per day of say 10 minutes only.

The feasibility of this option, as regards the risks involved and the limited capacity should be studied in detail if this option were to be considered.

Option 2 Navigation lock

The realization of a navigation lock will allow for 24/7 passage of ships, irrespective of the tidal situation at the Yangon River and the Pan Hlaing River. One option is to only allow passage at higher tidal stages, for which a less costly lock will suffice ('light lock version').

Moreover, as the shipping lock will most probably not be installed with a fresh-salt water separation system (which is very costly), some restrictions may also be imposed for prevention of salt-water intrusion e.g. no locking operations during the upcoming tide in favour of the outgoing tide. In spite of such potential restrictions, the utilization of the lock will still allow regular passage for ships during the majority of the day.

Additional remarks on navigation passage
Sedimentation in the Pan Hlaing River cannot be avoided totally, even after construction of the Pan Hlaing Sluice. This means that commercial sand mining could be an important asset to help maintain the river. However, navigation will have to be facilitated in that case. Within the framework of sustainable integrated development, worldwide a general agreement exists on the importance of inland navigation, as its ecological footprint is one to two orders of magnitude smaller than for other modes of transport[3]. A future-proof solution to maintain navigation on the Pan Hlaing River, hence would not exclude future shipping but is expected to further encourage present developments. This could be realized with a shipping lock, rather than with the opportunity of of brief passages for a very short period of time during slack tides underneath a raised gate.

Energy generation function
In the present design of the Pan Hlaing sluice the function of energy generation has not been identified. The NCEA is of the opinion that, outside of the dry season, energy can be generated from the flow from the Pan Hlaing River towards the Yangon River, from the excess water that is discharged via the sluice gates. Energy generation is possible as long as the water level at the Yangon River is lower than at the Pan Hlaing River, and assuming that the water that discharges via the turbines is really available, e.g. from excess drainage and base flows. Hence it can be expected, that outside of the dry season, such energy generation is feasible for periods of several hours, twice daily (due to the semi-diurnal tide).

The head difference is relatively small (up to a few meters maximum), so only low-head type turbines may be feasible. It is likely that propeller-type turbines will be best, which could be placed in slots in the gates, behind the gates, or in bypass channels.

The energy that will be generated will be relatively small, but might contribute to the energy demand of the sluice, as such contributing to a low or even a zero-emission sluice design. Examples [3] are shown below for the Afsluitdijk (IJssel lake closure dike near Den Oever) in the Netherlands (see Figure 4), as well as for the Eastern Scheldt Storm Surge Barrier (see Figure 5). The flow turbines are shown in raised position. The NCEA recommends to study the feasibility of energy generation by making use of flow turbines as an additional functionality in the comparison of the identified three locations.

[3] www.tocardo.com

Figure 4 Flow turbines at the Afsluitdijk	Figure 5 Flow turbines at the Eastern Scheldt Barrier
	

Bridge to cross the Pan Hlaing River

In the present design the sluice will not be used as a bridge to cross the Pan Hlaing river. If location 1 is selected in the mouth of the river this additional function might be considered, especially because the area south of the Pan Hlaing River will be developed as a residential area. It is expected that minor changes in the design can enable pedestrians, cycles and scooters to use the sluice as a bridge. It is recommended to include this function in the comparative assessment for the identified three locations.

The NCEA recommends:

- To include the aforementioned four (potential) additional functions in the project design of the sluice for the three locations identified, as far as relevant. The NCEA is aware that these four functions are probably only feasible when the project is located in the mouth of the Pan Hlaing River (Location 1). The EIA should elaborate the actual feasibility of the additional functions in coherence with the detailed structural design and operation of the sluice.
- In the EIA, the main characteristics of the Pan Hlaing Sluice Project fulfilling the seven functions needs to be described. For this description use can be made of the final feasibility study (Report no. 2).

5.3 Adaptive management of the sluice

A well-balanced decision on the design and location of the Pan Hlaing Sluice should be based on the EIA study that is developed in parallel with the detailed design study. However, the NCEA anticipates that major gaps in knowledge may remain due to the scarce data availability. This raises the question how to operate the sluice when those gaps in knowledge and information are expected still to exist after completion of the sluice. If so, as a practical way-out, the functionality and operation of the sluices may initially have to remain simple and robust to minimize the risks. At a later stage, after more hydrologic, hydraulic and morphological insight has become available, a more refined and optimized operation can be pursued, after sufficient in-depth study which also includes scenario-analysis for different situations, such as extreme events. At that stage, the multiple functioning of sometimes contradictory functions can be optimized further.

The NCEA recommends:

- that the detailed structural design of the Pan Hlaing Sluice should anticipate future refined operations, so the design should be robust and maximally adaptive.

5.4 Alternatives

The NCEA does not see an obvious activity alternative for the proposed sluice, which would achieve the main three identified objectives of the project.

The NCEA does distinguishes the following two project design alternatives that are worth exploring in the EIA. The first project design alternative (Alternative A) consists of the project as proposed and elaborated in the three aforementioned studies, serving three main functions: freshwater reservoir, mitigation of sedimentation and salt water intrusion and drainage function. In the second project design alternative (Alternative B) the four suggested functions as suggested in section 6.1 will be added to the proposed three main function.

Alternatives A and B need to be assessed and compared for the three different locations for the sluice that have been identified in the feasibility study (Report 2). Alternative A has already been assessed and compared for the three locations in a qualitative way by making use of the following five evaluation criteria:

- amount of water in the system;
- water quality;
- sedimentation in front of the sluice;
- planning;
- costs.

The NCEA recommends:

- to elaborate two project design alternatives: Alternative A providing the three original functions and Alternative B providing the three original and the four new functions;
- to make a comparative assessment of Alternative A and B for the three identified project locations. In case alternative B is not feasible for one or two locations this needs to be justified in the EIA;
- in addition to the five abovementioned criteria, the following evaluation criteria are proposed for the comparative assessment:
  - amount of water available for irrigation of 50.000 hectare;
  - market value of the additional yield / crop as a result of the water extracted from the reservoir in the dry period (a minimum and maximum estimation needs to be justified);
  - amount of water available for domestic use, in terms of number of domestic users (at least 2 million) and industrial use (based upon estimated future use of industries);
  - passage by ships in number and size per year, and near-future projections;
  - adaptability of the expansion of the sluice capacity in future, when an increase in discharge capacity is expected due to amongst others climate change effects;
  - indicative investment costs for the sluice, for the full range of (feasible) functions, with and without a navigation lock ('light version').

6. Description of the environment

The EIA process needs to start with a clear description of the proposed project, including details such as siting, design, size and phasing. The scoping stage can be utilized to further refine and clarify the project description, if needed, so that the project activities can be clearly described in the scoping document. Consideration of alternatives also takes place during scoping. Alternatives to a proposal are identified and explored. Identification and comparison of alternatives will help to determine the best method of achieving the project objectives while minimizing environmental and social impacts or, more creatively, indicate the most environmentally friendly or best practicable environmental option. At the end of the scoping stage, it should be clear which alternatives will be explored further in the EIA, and how these will be compared.

Setting the study limits (demarcation of the project and study area)

The *project area* is the area where the project will be constructed. The NCEA suggest that *the study area*, which is the area affected by the proposed Project, should include at least the following four areas.

- Pan Hlaing River:
  - Pan Hlaing River in between the Mezali Sluice 2 and Pan Hlaing Sluice (hydro-morphodynamic influence, water quality influence);
  - Pan Hlaing Sluice outflow at the Yangon River (e.g. cross-currents relevant for navigation);
  - Riverine economical activities: navigation, fisheries, sand mining etc;
  - The offtake section from the Ayeyarwady River and potential backwater effects (up to Nyaung Done area).
- Irrigation areas to be fed by the Pan Hlaing River and farmers owing or working in these areas.
- River bank:
  - riverine villages;
  - riverine drainage areas, including industrial areas.
- Yangon & Kokkowa river:
  - the Kokkowa River, in interaction with the operation of Mezali Sluice 2 and the effect of tidal distortion and changes in salt water penetration due to the Pan Hlaing Sluice;
  - the Yangon River, with respect to prevention of tidal water to enter the Pan Hlaing Sluice and with respect to the changed drainage pattern;
  - interaction, via the Yangon River, with the proposed Sluice in the Twante canal;
  - future Yangon extension (in between Pan Hlaing River and Twante Canal);
  - potential adverse effect on hurricane storm surge levels for a larger area of Yangon and tributary rivers, in case that the Pan Hlaing Sluice will be operational to arrest storm surges to enter the Pan Hlaing River.

Main users or stakeholders

Main groups of users or stakeholders that have so far been identified and presently make use of services provided by the identified main project study areas:

- Farmers living and working in the command areas on the northern side of the Pan Hlaing River. A distinction need to be made between men and women.
- Labourers: there is a group of people who do not own land, or own land that cannot be irrigated at present. They generate (additional) income by providing labour to farmers or day labour (e.g. sand mining in the riverbed during the dry season).
- Boat owners and crew/traders/ship yard: the owners and crew of boats who are responsible for transport of people and cargo in the Pan Hliang River and boat owners involved in sand mining. Moreover, at least one ship yard is located on the southern side of the river.
- Fisher folk: local people whose livelihood (partly) depends on fishing (river and fish ponds) and fish product manufacturing.
- Industries located in the industrial zone on the northern side of the Pan Hlaing River that use the river for transport an drainage.
- Residents living in communities on the river banks as well the future residents that will live in the residential areas to be developed in the area south of the Pan Hlaing River (two million are foreseen).
- Users of the study area not yet identified: potentially there might be other users that have not yet been identified but need to be considered.

The size of each of these groups needs to be estimated and other relevant groups, if present, would need to be identified and taken into consideration in the EIA study.

Main services provided by the study area

In table 2 the preliminary main services provided by the landscape units of the study area, are listed. The main user groups of the services have been identified. This list of services and users has been elaborated during a desk study and a one day field visit by the NCEA and is therefore not expected to be exhaustive. The NCEA would like to emphasize that the EIA study should focus on the main services used by the different user groups that might be affected (positively or negatively) as a consequence (directly or indirectly) of the implementation of the proposed project. The NCEA recommends to use this table in the EIA and make it complete.

Table 2: Preliminary assessment of the main ecosystem services presently provided by the identified landscape units for the main user groups.

Main project study areas	Main services	Study area – main users					
		Farmers land owner	Labourers	Boat crew & owners	Fisher folks	Industries	Residents
Pan Hlaing River reservoir	- Irrigation water	X	X	-	-	-	-
	- Domestic / industr.water	X	X	X	X	-	-
	- Transport	?	-	X	X	?	?
	- Food / fish	-	-	-	X	X	X
	- Habitat for diseases	?	?	?	?	-	-
	- Sediment	-	-	X	-	?	?
Irrigation command area	- Food	X	X	-	-	-	-
	- Irrigation water	X	X	-	-	-	-
River banks	- Use of banks	X	X	X	?	X	X
Yangon / Kokkowa river	- Irrigation water	?	-	-	-	-	-
	- Sediment	?	-	-	-	-	-

Food (agriculture) and water

- Water supply for irrigation/fish ponds: the irrigation command area with an estimated size of 50.000 hectares receives supplementary irrigation during the wet season. The present use of water from the Pan Hlaing River during the wet and the dry season needs to be described. The present agricultural production characteristics as well as the socio-economic position of the farmers/labourers need to be described in the EISA study.
- Domestic water supply: the use, amount and origin of water (surface water / boreholes) used for domestic and industrial purposes should be described in the EIA study.
- Water quality and sanitation: the industries located in the industrial zones on the northern banks of the Pan Hlaing River are sources of pollution that affects the water quality. The majority of the industries drain untreated waste water though six main drains into the Pan Hlaing River. There are strong indications that this drainage water is heavily polluted. Residents living in this industrial zone are affected by the present level of pollution and poor sanitary situation. The industrial zone is presently being extended to the west and this might further increase water pollution. In the EIA, the basic water quality of the Pan Hlaing needs to be assessed – by making use of measurements made – during the wet and the dry season (preferably make use of measurements made during the dry season when the coffer dam was closed). The suitability of this water needs to be assessed on the following purposes: irrigation water, industrial use, domestic use, drinking water.

Transport

- River transport: The Pan Hlaing River provides the opportunity for year-round transport of people and cargo. In the EIA study, an overview should be provided of the present use of the river by different types of boats, amount and type of cargo and passenger transport as well as a near future projection of the use.

Sedimentation and erosion

- Natural erosion and deposition of sediment/silt: forces of erosion and deposition are strong due to the highly dynamic character of the Pan Hlaing River and the tidal influence of the Yangon River. A number of boats are generating income by sand mining. In the EIA report the present situation should addressed as far as relevant for the project area.

Health

- Providing habitat for disease transmitting organisms: the creation of a fresh water reservoir may enhance the reproduction of freshwater related water borne diseases such as mosquitoes and bilharzia. This depends on the type of vector species and their ecology. The risk of infection greatly depends on availability and reliability of public water supply and vigilance of primary health care services. In the EIA study, the present risk of water borne diseases that are likely related to the standing and receding water in the reservoir during the dry season needs to be described.

Fisheries / biodiversity

- Influencing fisheries/biodiversity: The downstream area of the Pan Hlaing River is under daily tidal motion and thus will have predominantly brackish water, apart from high river flow situations during the wet period, in which the water will be fresher. In the dry period, the water may even be in the salty range. After the construction of the Pan Hlaing Sluice, salt water will be prevented to enter, so the river and riverine waters will become predominantly fresh. This will have a considerable influence on the fisheries resources, the natural vegetation on the river banks and floodplains (especially at the southern side) and the biodiversity dependent on these resources and vegetation. In the EIA study the present importance of the Pan Hlaing River needs to be described for the populations of important fish species (important because of commercial value or because of a threatened or protected status) and other biodiversity.

7. Key potential impacts and mitigating measures

In an EIA the expected impacts of the identified proposed project and design and location alternative(s) need to be described. This facilitates a comparative assessment of these alternatives. Mitigating measures to minimize the negative expected environmental and social effects need to be identified and described, and an assessment needs to be made to what extent they can remedy the negative effects. During scoping the relevant impacts needs to be identified and prioritized, and it should be decided which impacts need to be further assessed in the ESIA, and how. Promising mitigation measures to be developed further in the ESIA need to be identified during scoping as well. It is also useful to look ahead to the environmental and social management plan for the project, and consider what topics will likely need to be addressed in this EMP, and how this EMP should be furthered developed in the EIA.

7.1 Impact assessment

Starting point for impact assessment are the ecosystem services that are listed and described in chapter 5. Impacts on these ecosystem services from the project, need to be quantified as much as possible for the identified alternatives, by following a four-steps approach:

7.1.1 Step 1: Describe the ecosystem services

In Chapter 6 a preliminary list of ecosystem services is provided. Describe and quantify the actual services provided and subsequently identify the main services and focus on these services in the steps 2 to 4.

7.1.2 Step 2: Changes in ecosystem services

Describe and quantify the expected change of ecosystem services for Alternative A and B and for the three identified locations. Suggestions for the way in which services can be expressed for each of the three identified main project study areas and the Yangon / Kokkowa river are provided below.

Pan Hlaing River

- Transport
  - Expected change in the intensity of water transport for cargo (size of boats and cargo specified per type) and passenger transport in the study area.
  - Describe the risks of accidents (safety of small boats and passenger transport) and the risks and consequences of spills of hazardous substances (oil, fuel, cement, other).

- Fish / biodiversity
  - Fish migration will be blocked by the seasonal reservoir and will, outside of the flood season, only be possible within the main channel in between the two sluices. Effect on aquatic life of this change in migration needs to be described.
  - With the construction of the reservoir, small pools of water, which serve as spawning and nursery ground for fish may disappear. This potential change needs to be described in the EIA study.

- Impact of turbines on mortality of fish and other aquatic life needs to be described, when turbines would be considered for energy generation.
- Safety risks of the (partly) opened sluice, turbines, electricity storage and distribution needs to be described for the local population and fishermen fishing close to the sluice.

- Sediment
  - Describe the expected qualitative change in sedimentation and erosion for the section downstream and upstream of the project area, and the potential risk of hampering navigation in those sections.
  - Assess to what extent the lifetime and the storage capacity of the seasonal reservoir might be affected / will change due to sedimentation and to what extent the operational regime have an impact on this lifetime and storage capacity.
  - We note here that relevant data and information may be lacking for projection of sediment and bed level changes. Therefore, the utmost should be pursued to fill this knowledge gap during the detailed design of the Pan Hlaing Sluice. This is also of importance to anticipate on the desired sluice management (O&M planning), together with the water function described below. The potential effects of climate change need to be considered in terms of e.g. considerable change in sea level, change between the dry and wet season, discharge of the Ayayarwady river.

- Water
  - Describe to what extent the water quality might be changed when the water will be more isolated due to the construction and operation of the Mezali sluice 2 and the Pan Hlaing Sluice.
  - The improved availability of irrigation water will enhance agricultural production. Especially in the dry season, more water will become available, generating the potential to introduce more crops per year or to increase the irrigated area. When the water becomes available at a fair price to small farmers, it can support poverty alleviation. However, when only large-scale commercial farmers will benefit from the water reservoir, this may threaten small farmer's livelihood and create more competition over irrigation water. This possible difference between large and small farmers needs to be described in the EIA.

- Mining
  - It should be described how the project will affect the livelihood of the boats and crew involved in sand mining.

- Health
  - Describe the potential change in the occurrence of water-related diseases like bilharzia, malaria and dengue.

Irrigation command area

- Food /agriculture
  - Assess the following possible changes on the agricultural production opportunities and expected gender specific socio-economic changes for the farmers and labourers of: (i) the additional supply of irrigation water; (ii) more efficient use of irrigation water and better cropping and (iii) risk of leaching (due to absence of drainage).

- River banks
  - Assess the consequences of the changing water level regime, as well as changing water quality regime (especially salt/fresh) on the usage and functions of the banks, such as residential area, bank access, agricultural and other economic usage, drainage.

- Yangon / Kokkowa river
  - Assess the potential effects of the functioning of the Pan Hlaing Sluice on tidal distortion, rain storm flood levels and storm surge levels in a wider area of the Yangon River and the Kokkowa River, also for the situation that a Sluice in the Twante canal has been constructed.
  - Assess the changes in salinity intrusion in the Kokkowa river and the (additional) effects on the irrigation command areas which are planned to benefit from the Pan Hlaing Sluice project.
  - Assess the potential backwater effects (up to Nyaung Done area) in the section of the Pan Hlaing / Kokkowa river after the offtake form the Ayeyarwadi river.

7.1.3 Step 3: Affected stakeholders

See chapter 6 for an indicative list of stakeholders that make use of the services that might be affected. Different services may have different areas of influence. In addition to the direct users of the services that have been identified in Chapter 6, one could also think of the following groups of stakeholders:

- government authorities responsible for policies and compliance; and
- non-governmental organizations.

It is important to realize that the identified stakeholder groups may not be homogeneous groups. The project may have different effects on people with different socio-economic status, and on women and men in the same stakeholder group (especially farmers and labourers) who may undertake different tasks. Different people within the same stakeholder group may therefore be affected differently by the proposed project. This difference in effects within a stakeholder group needs to be described in the EIA, when relevant.

7.1.4 Step 4: Assessment of the change of services

The NCEA recommends to make use of a Multi Criteria Analysis (MCA) to value the changes of services. An MCA is designed to make quantitative comparisons between such varying expressions of values and is very useful when impacts cannot easily be expressed in financial terms. The changes in ecosystem services are expressed in terms of changes in social and economic values for stakeholders. Values can be expressed in their own terms, such as number of employed people, agricultural production, number of people served by public water supply, contribution to gross regional product. The NCEA advises to make use of interviews with experts and key resource persons, reinforced by consultation with (representatives, gender specific of) the farmers/labourers from the irrigation scheme to describe the importance of the different changes.

7.2 Cumulative impacts

The Pan Hlaing Sluice will be a unique structure in itself. It is thinkable however, that is due time a tidal barrier may also be proposed in the Kokkowa River mouth. In that case, there may be a certain interaction between the effects of both sluices. A similar interaction may apply to a future Sluice in the Twante Canal.

The NCEA recommends:
That the potential interaction between the Pan Hlaing Sluice, a potential tidal barrier in the Kokkowa River, as well as a future Sluice in the Twante Canal should further be explored. This exploration includes separate and mutual positive and negative effects on rainstorm and storm surge flood levels, dry period levels, fresh water availability and other environmental impacts. A focal point should be placed on potential adverse cumulative impacts, against the background of the mutual functioning of the structures. Where possible, the mutual functioning should be adapted such as to mitigate the adverse cumulative effects.

7.3 Mitigating measures

The NCEA notes that the pollution of the water quality in the reservoir, due to untreated inflow of waste-water drainage from the industries north of the river, is a key impact that threatens the achievement of the overall objective of the project, namely providing fresh water for irrigation and domestic purposes in the dry season. To secure that fresh water standards for irrigation and / or domestic use will be met, the waste-water drainage needs to be solved before the project can be constructed.

Other negative environmental and /or social effects might need to be mitigated as well.

The NCEA recommends:

- To apply an integrated approach to solve the issue of water pollution as part of the successful realization of the project. This pollution primarily involves heavily polluted water, as well as plastic debris that is abundant at the industrial site. Therefore, in the EIA the following mitigating measures need to be elaborated and compared to find the most feasible option to solve the untreated drainage of water in the reservoir:
  - clean-up of the industrial site of plastic debris and implementation of a collection system;
  - centralized waste water treatment for the present and future industrial zones;
  - waste water treatment facilities at the level of individual industries or related group of industries; such plants need to be elaborated, partly in combination with more centralized treatment;
  - collecting and diverting the waste water away from the reservoir by a waste water pipeline that discharges into the Yangon River has been suggested by officials of MoALI during the field visit of the NCEA. Although this option is beneficial for the reservoir, it does not solve the problem of drainage of untreated waste water in the Yangon River. This option can be described in the EIA as a temporarily measure for example in the case the sluice is constructed before the waste water treatment facilities are in place.
- Other mitigating measures need to be elaborated in case necessary.

8. Environmental management plan

An environmental management plan is a site-specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislation.

The environmental management plan needs to be part of the EIA according to the Myanmar EIA procedure. The NCEA recommends to prepare the environmental management plan when the location and preferred alternative have been decided.

9. Lack of knowledge and information

It is important to acknowledge gaps in knowledge and information in an ESIA. During scoping key gaps in information can already be identified, and strategies decided to deal with these gaps. Appropriate responses could be to gather missing information within the ESIA process, but it may also be fitting to develop adaptive management responses to deal with information gaps that are unlikely to be resolved.

During our short study, the NCEA already encountered at several places information on major issues seems to be lacking. In the list below, some obvious gaps in knowledge and information that have been identified by the NCEA are summarized. The list is only indicative.

- There is a general lack of hydro-geomorphological as well as hydrological information. Systematic measuring campaigns have not been implemented yet. The PHRIDP study gives an extensive list of recommendations for additional studies (Section 11.4).
- A specific lack of knowledge exists on the present (baseline) situation, with the Mezali Sluice 2 in place and an extensively dredged river. Basic insight in operational strategies for Mezali Sluice 2 seems to be lacking, as well as the effects on the autonomous situation (especially salt intrusion and re-sedimentation). The potential effect of temporary closure of the cofferdam seems also to be highly unknown (which may be relevant as long as the Pan Hlaing Sluice has not been built).
- The Mezali Sluice 2 operations will have an effect on the Kokkowa River, but this has not been studied yet. In the future, when a tidal barrier would also be considered for the Kokkowa River mouth, the Pan Hlaing Sluice, acting together with the Mezali Sluice 2 may interact with the a tidal barrier in the Kokkowa River.
- Better insight in navigation intensities and future prospects would be useful to reconsider the construction of a shipping lock.

The NCEA recommends that in the EIA study the existing gaps in knowledge and information are described and an assessment is made of the risks to fulfil the objectives of the project.

10. Public consultation and disclosure

Scoping should be an interactive process, during which key stakeholders are consulted. Key stakeholders include the affected communities as well as relevant government institutions and knowledge institutes. These stakeholders should have an opportunity to contribute information to the scoping process, but also to express their views on alternatives, impacts and mitigation measures. These views should be reflected in the scoping conclusions. The scoping report should also present a stakeholder engagement plan for the remainder of the EIA process.

The Myanmar EIA procedure (adopted January 2016) provides specific guidelines for public consultation and disclosure. These need to be followed.

The NCEA provides some project specific recommendation for public consultation.
In Chapter 6 of this advisory report the primary stakeholders or users making use of the main ecosystem services have been identified. Those stakeholders might directly be affected by the project. Public consultation with these stakeholders serves to inform the stakeholders and avoid unintended (negative) consequences. Village meetings are important, which further need to ensure that perspectives from women and men are taken into account. It is important to realize that not all community members (women/men; ethnicity; wealth; age) will have equal voice. Local community and women's groups and local and (inter)national NGOs may complement findings from community consultation. Direct stakeholder consultation furthermore is an important tool to encourage project collaboration, to prepare people for anticipated changes and to raise realistic expectations.

Other stakeholders include government authorities, consultation with these stakeholders serves to ensure coherency between and alignment with other government policies and plans. As part of the EIA report, inter-ministerial consultations need to take place. Apart from MoALI the Yangon Regional authority needs to be consulted as they have plans for development of the area south of the Pan Hlaing river.

ANNEX 1: Letter requesting advice by MoALI

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The Republic of the Union of Myanmar

Ministry of Agriculture, Livestock and Irrigation

Irrigation and Water Utilization Management Department

Ref. Letter No. 7586 / Dapa Lana (31) Twe (6).

Date: 12th December 2016

Mr.Rob Verheem
Director
Netherlands Commission for Environmental Assessment (NCEA)
PO Box 2345
3500 GH 4TRECHT
The Netherlands

Subject: Request to provide assistance for ESIA procedure in Pan Hlaing Sluice Project

Dear Mr. Rob Verheem

I would like to introduce by myself firstly. My name is Kyaw Myint Hlaing (Mr). I am writing this letter with my capacity of the Director General of the Irrigation and Water Utilization Management Department under the Ministry of Agriculture, Livestock and Irrigation, the Government of the Republic of the Union of Myanmar.

We have started the Pan Hlaing Sluice Project since 2014 as one of the learning by doing projects that is continuing cooperation and collaboration among the government of the Netherlands and our Myanmar government according to the MoU signed between the Netherlands Ministry of Infrastructure and Environment for the Netherlands side and the Ministry of Transport and Communication on behalf of the National Water Resources Committee (NWRC) for Myanmar side in 2013. Accordingly, we have received assistance from the Netherlands Enterprise Agency (RVO) to study the feasibility and sketch design phase of the Pan Hlaing Sluice Project together with Dutch consulting consortium leads by Royal Haskone DHV and composing the Deltares and TU Delft.

The current status of the Pan Hlaing Sluice Project is completed stage of the feasibility study and sketch design phase of the project. The Netherlands Enterprise Agency is continuing to provide assistance for the final design phase of the Pan Hlaing Sluice Project. After that, for implementation of the project, we are intended to request the Netherlands government to finance partly via the DRIVE facility.

In this regards, the Environmental and Social Impact Assessment (ESIA) study is one of the pre-requisites for applying the DRIVE facility. Thus, we would like to request to provide assistance for ESIA procedure in Pan Hlaing Sluice Project with your Commission's esteems experiences in this matter. We are hoping that your Commission's provided assistance may secure the quality of the ESIA study as well as capacity development of officials from our department in this concerned for future projects.

Thank you very much in advance for your possible kind assistance and we are looking forward to receive your response as soon as your convenience.

With best regards

13.12.2016

Kyaw Myint Hlaing
Director General

c/c to

1) Dr. Zaw Lwin Tun, Director, Design Branch, Irrigation and Water Utilization Management Department, Yangon
2) Director, Planning and Works Branch, Irrigation and Water Utilization Management Department, Naypyitaw
3) Office copy

ANNEX 2: Evaluation of IFC performance standards

Conclusion: The following PSs are triggered: 1,2 3, 4, 6, potentially triggered is 5. For further assessment of the PS s triggered see the attached assessment.

PS	Assessment
PS1: Assessment and Management of Environmental and Social Risks and Impacts	Triggered • Anticipating the EIA procedure in Myanmar (adopted January 2017). The EIA needs to fulfill these requirements.
PS 2: Labour and Working Conditions	Triggered • The workers involved in the construction of the Sluice. • In the advice for the scoping report for EIA this issues has not been included. The labour and working conditions during the construction phase of the project to be elaborated in the EIA report.
PS 3: Resource Efficiency and Pollution Prevention	Triggered • In the NCEA advisory report it is recommended to add an addition function namely energy generation by making use of flow turbines. • In the advisory report pollution of the freshwater reservoir due to untreated discharge of poisonous water in the Pan Hlaing River is indicated as an important source of pollution. It is recommended to elaborate a good practice solution(s) in the EIA also because it directly affects the main objective of the project namely provision of fresh water for agricultural, domestic and industrial purposes.
PS 4: Community Health, Safety and Security	Triggered • People living in the industrial area on the northern side of the Pan Hlaing River are living in an unhealthy environment due to the fact that they are living along the open canals that are used to drain the untreated and polluted industrial waste water. Although these people are not directly affected by the proposed project, the NCEA has recommended to elaborate a good practice solution for the untreated discharge. This means that the people living along the open drainage canals will benefit.
PS 5: Land Acquisition and Involuntary Resettlement	Potentially triggered • This PS does not trigger the proposed project. However, the NCEA recommends in its advisory report to add another function to the project, namely a storm surge barrier function. In case this function will be adopted, this means that especially along the southern side of the Pan Haling river the river banks need to strengthened and that might trigger this PS. In the advisory report for the scoping report for the EIA the

	possible involuntary settlement has not been addressed. During the EIA study it will become clear whether this PS will be triggered. In case it does, the procedure elaborated in the IFC procedure need to be followed.
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	Triggered • The Pan Hlaing River or the study area affected by the project are not protected areas. However, the existing biodiversity that is dependent on the Pan Hlaing River will completely change because a brackish system will be changed into a fresh water system. In the NCEA advice for the scoping report for the EIA it is recommended to study these effects.
PS 7: Indigenous Peoples	Not triggered
PS 8: Cultural Heritage	Not triggered

In the NCEA advice for the scoping report for the EIA for the Pan Hlaing Sluice project guidelines have been provided for the following PSs: 1, 3, 4 and 6.
PLEASE note that for the PSs 2 and 5 no guidance has been provided in the NCEA advisory report but these PSs need to be considered in the EIA.

(Based on FMO & Steward Red queen Environmental, Social and Governance (ESG) toolkit, the IFC online course and webinar, and other sources)
(See also: http://www.ifc.org/performancestandards)

ANNEX 3: NCEA Field trip observations

At 19 January 2017 a field visit was arranged by the MoAI and the Netherlands Embassy. The arrival at the site was by car at the northern approach to the temporary cofferdam. This location has been denoted as Location 2 in the feasibility study of the Consultants. The cofferdam was followed by foot and the field survey party embarked at the end of the cofferdam in two small boats, see Photo A4-1.

The cofferdam has been opened to allow for discharge during the wet season, but in contrast to previous years when the dam was closed during the dry period, it has remained open now. A major part of the dam is still present (the abutment end is provided with a sheet piling face to prevent erosion, see Photo A4-2. At the south side of the river part of the dam is still present as well, however with an unprotected face. During the boat trip the stage of the tide was upcoming high water with only moderate flow velocities. The latter can be attributed by the wide funnel shaped river at Location 2 which was further increasing towards Location 1 near the mouth of the Pan Hlaing River. The water turbidity was considerable, showing a high concentration of fines that entered the Pan Hlaing River during the boat trip.

Near the river mouth, the most likely location for the Pan Hlaing Sluice (Location 1) was identified, see Photo A4-3. Location 1 is at a relatively narrow section near the river mouth. Just inland of the planned Pan HLaing Sluice is a shipyard that builds ferry boats, see Photo A4-4. The south side of the location is characterized by a relatively wide floodplain with rather dense vegetation, including low mangrove shrubs. The north side showed a river bank which was raised as part of the extension of the Pan Hlaing golf estate (high-end villas).

Somewhat further east, at the river mouth north bank we disembarked for a visit to the estate guard stronghold, see Photo A4-5, at which an exhibition was given on the proposed Pan Hlaing Sluice, see Photo A4-6. The exhibition also pinpointed the safety that would be offered by the Pan Hlaing Sluice.
The east river bank of the estate, bordering the Hlaing River, has been lined with a relatively new vertical protection wall and the bank levels are relatively high already when compared to the lower banks more inland, see Photo A4-5. This rose the question in how far storm surge protection against cyclones could be provided by the Pan Hlaing Sluice when positioned in the river mouth. The efforts to further secure the connecting dikes seem potentially feasible.

Sailing back, along the river stretch in between Location 1 and Location 2 no major sewage outfalls could be seen (but this might have been due to the heavy vegetation). A few small dredgers were dredging sediment from the river bed, see Photo A4-7. Low-intensity fishing activities (series of nets extending from the north bank) could also be seen. The north bank is generally well-vegetated with rather good access to the river via man-made access spots, often combined with economic riverine activities.

After disembarking again at the cofferdam, we proceeded towards the Pan Hlaing Bridge site (Locaton 3) via the industrial area. We stopped by one of six major outfall channels, which showed nearly black, dirty smelling, poisonous waste water. Dwellings of the local inhabitants were situated along the outfall, showing a serious healthy issue, see Photo A4-8. The industrial area road sides were covered with litter, especially plastics, much of which collect-

ed in the drains. Many people had their houses along the roads and along waste water outfall channels. Only two major factories (paint and pharmacy) were reported to have their own waste water treatments systems. For the field survey party the visit to the (older) industrial area is was a rather shocking experience and demonstrated the huge effort required for sanitation of this area. Approaching Location 3, more recent industries could be observed which showed within their premises well-planned and clean areas.

Location 3 at the Pan Hlaing Bridge site showed a much smaller river cross-section, characteristic for the river upstream, see Photo A4-9. Surprisingly, intensive boat traffic could be observed downstream of the bridge, including: transport barges, tugs, dredgers (carrying sand from the Hlaing River for the industrial expansion). Upstream of the bridge there were construction works going on and only modest inland navigation could be observed.

At our request we proceeded further upstream along the main road via agricultural lands, paddy fields, fish ponds, with a focus on irrigated areas, see Photo A4-10. Supply of irrigation water seemed to be sufficient during the site visit (water partly coming from the Kokkowa River, from which we also saw a major supply channel and distant inlet, see Photo A4-11. Our guides however indicated that more water from the Pan Hlaing River might lead to multiple crop periods as well as to extension of irrigated lands. At multiple occasions it was reported that an in-depth quantification of the irrigation water demand for various development scenario's has not been made so far, although a rough assessment was made prior to the large-scale dredging of the Pan Hlaing River. We note here that in the PHRIDP study, the irrigation water demand was assessed as well as to produce water balance estimates.

Next the visit by road proceeded to the most upstream location, i.e. the recently constructed Mezali Sluice 2 in the Pan Hlaing River, near the confluence of the Kokkowa River, see Photo A4-12. The Mezali Sluice is designed as an inflow regulator towards the Pan Hlaing River and is said to be mainly operated such that in the dry times the sluice is opened and in the wet period it is closed. In addition, supplementary to an open/closed regime, the flow towards the Pan Hlaing River can also be well-regulated via sector gates that also have been installed and can be operated manually. We were not reported on the operational regime in the transition seasons, nor has it been outlined in the PHRIDP study. The operational strategies, also for extreme conditions and for emergency conditions, seem to be not yet elaborated. For daily operations a proper operational strategy is considered especially relevant for the transitional seasonal periods in between the dry and wet periods.

Obviously, in spite of the recommendations made in the PHRIDP report to tune in the construction of the Mezali Sluice 2 with the proposed Pan Hlaing Sluice, the authorities have decided to already construct the Mezali Sluice 2. We think that this may have been done to avoid strong sedimentation during the wet season (from heavy silt laden flows from the Ayeyarwady, entering the Pan Hlaing River; this will be avoided now by closing this sluice).

Photo A4-1: Embarking on the small ferryboats

Photo A4-2: Northern protected temporary cofferdam face (left) and unprotected southern face (right)

Photo A4-3: Location 1 looking south (left) and looking north (right)

Photo A4-4: Shipyard directly inland of Location 1 (southbank)

Photo A4-5: Golf estate guards stronghold (Pan Hlaing side left en Hlaing side right)

Photo A4-6: Exhibition at golf estate guards stronghold

Photo A4-7: Typical local dredging activities

Photo A4-8: One of the open water drains in the industrial area (left) and plastic clogging (right)


Photo A4-9: View of navigation activities downstream of Pan Hlaing Bridge


Photo A4-10: Typical irrigated fields (left) and water supply channel (right)


Photo A4-11: Helpful discussions (left) and Kokkowa supply channel (right)

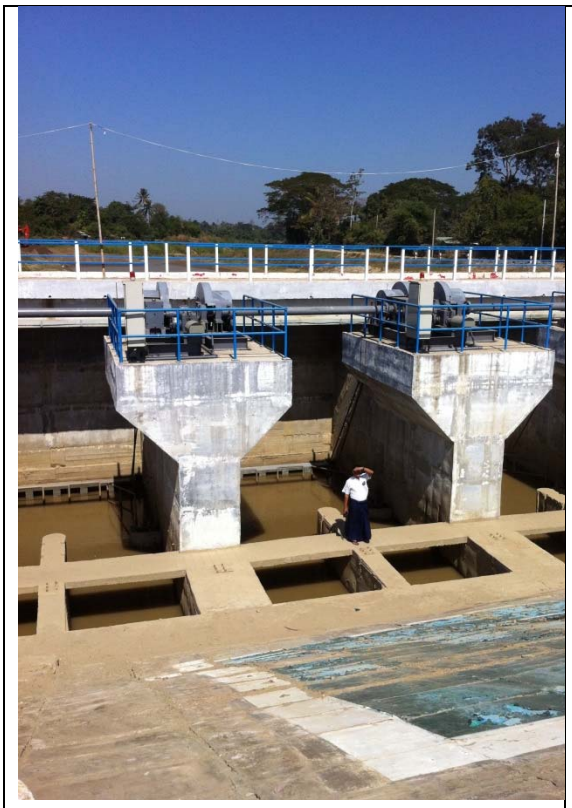

Photo A4-12: Mezali Sluice 2 close to the bifurcation with the Kokkowa River: upstream view (left) and downstream view (right)

ANNEX 4: Appraisal of the available studies

In this Annex, the Pan Hlaing Sluice project is reviewed more in depth, based on the two major reports:

(1) PHRIDP: Pan Hlaing River Integrated Development Plan (30 October 2015):
This report focuses on the integrated idea, the idea, approach and overall setting.

(2) Final Feasibility Study Pan Hlaing Sluice, Myanmar (8 April 2016):
This report is elaborating more quantitatively on the feasibility of the Pan Hlaing Sluice and includes a sketch design of it.

A5.1 Appraisal of the PHRIDP report

The PHRIDP report shows a systematic set-up of the studies required for this initiative. At the start of the study relevant data were largely lacking. It is recognized that a major part of the knowledge and findings was obtained via a process of increased understanding, as can be expected in this complex type of projects, within the present setting in Myanmar. Building a knowledge base at which the project could be developed has been a time-consuming effort and is highly acknowledged.

The gradual increase in knowledge may also explain the not always logical arrangement of subjects and chapters in the report.

Very helpful for the reader to get a quick insight of the report contents is the comprehensive executive summary.

<u>Major functions (Chapter 2 of the PHRIDP report)</u>

Fresh water function

The major reason for the project is indicated in Chapter 2 (Introduction): since about 5 years ago the Pan Hlaing River was totally silted up and hence was unable to discharge rainstorm water from the area. As a result, the surrounding farmland flooded which decreased yields and caused crop losses. Furthermore, in the dry season the water supply for irrigation was strongly reduced. In 2014 the Irrigation Department (ID), via the Myanmar President's fund, rehabilitated the Pan Hlaing River for irrigation (20 m^3/s) by dredging the river and by constructing a temporary cofferdam downstream that was closed during the dry season. Furthermore an upstream sluice has been built near the Kokkowa River bifurcation by which the discharge towards the Pan Hlaing River downstream of the bifurcation can be regulated.

Apart from this rehabilitated function by the measures taken above (in which the temporary cofferdam should be replaced by the more sustainable Pan Hlaing Sluice), fresh water demand is expected to increase, e.g. by increasing industrial activities north of the river, the potential Yangon city expansion in between Pan Hlaing River and the Twante Canal (envisaged population 2 million!) and luxury estate development near the river mouth at the north bank.

Flood control function

Better control of water levels has been identified as a second major function, in order to prevent or at least mitigate flooding from heavy rainstorms. We note here that control of short duration storm tides by cyclones has not especially been addressed.

Additional functions

At instigation of the Government of the Netherlands, the idea of construction of a sluice at the Yangon side of the Pan Hlaing River to meet the above objectives, has been placed in a wider context, which resulted in the PHRIDP report.

This integrated study identified the importance of prevention of saltwater intrusion from Yangon River towards the Pan Hlaing River, as to reduce siltation and as such contribute to a more sustainable situation in which future dredging efforts will be reduced.

Approach and phasing of the project (Chapter 3 of the PHRIDP report)

The project development of the project was realized through three stages (see Chapter 3 of the PHRIDP report):

- *The analysis phase*: understanding of the overall system via policy and stakeholder workshops and analysis, preliminary data analysis.
- *The vision phase*: translation of the requirements, data, boundary conditions from the analysis phase into an integrated vision within the PHRIDP. Stakeholder interaction is considered essential for this translation.
- *The feasibility and sketch design phase*: with emphasis on the development of a viable project, the sketch design of the Pan Hlaing Sluice is being drafted.

  Oviously, the first two phases are incorporated in the PHRIDP report, whereas the third phase has been reported in the Feasibility Study.

Data analysis (Chapter 4 of the PHRIDP report)

The recovery of relevant data was a huge and challenging effort for all parties involved, as systematic data measurements were largely lacking. Apart from extensive data requests to many departments, with sometimes limited success (lacking data), several site visits and stakeholder meetings have been organized. In the end a part of crucial data could not been obtained, e.g.: (larger) system understanding, detailed urban planning development plans, water quality data and specific topographic data. As a consequence, after data evaluation, assumptions still had to be made. Direct involvement of the ID staff enabled assumptions to be generally agreed upon. In addition, a SOBEK hydrodynamic model was utilized to improve the knowledge of the present conditions in the river system. Specific expertise (engineering judgement) was added by experts of the consortium, in close co-operation with experts of the ID, to this model where crucial data were lacking.

Relevant missing data were identified, see Table 4.1 of the PHRIDP report, relating to river system understanding, urban development, water quality and water balance. After consultation with the stakeholders consent was obtained on the assumptions and considerations. Hence, in spite of lacking data, the knowledge base grew in time by the knowledge of experts, by the SOBEK modelling simulations and by the joint effort of stakeholders.

Stakeholder analysis (Chapter 5 of the PHRIDP report)

Crucial to obtaining data and consent about the project requirements, as described above, were the stakeholder meetings that were held on instigation of the consortium. A huge effort was done to identify review relevant stakeholder organization and key representatives and to collect information from numerous stakeholder meetings.

The consortium applied a systematic approach to collect and analyze the existing information. Major stakeholder requirements have been reviewed in Section 5.3 of the PHRIDP report.

Natural delta system (Chapter 6 of the PHRIDP report)

A scientific basis was largely lacking prior to commencement of the study, so a lot of effort was put in further study of the delta system. This is especially relevant, as sedimentation may be caused by the Ayeyarwadi River (which brings in a lot of water and sediment during the wet season) as well as by the tidal Yangon River from which daily tidal flows enter the Pan Hlaing River. Understanding of this hydromorphological system is of the utmost importance for assessing the potential effect of the Pan Hlaing Sluice.

One of the major observations was the large quantities of mud in the Pan Hlaing River. This pinpoints to origin from the Yangon River. Moreover, salinity calculations showed that during daily flood tides saline water enters the Pan Hlaing River more than halfway from the mouth of the river and the Kokkowa River bifurcation. Saline water, when meeting fresh water, gives the so-called 'turbidity maximum' which is an area in which fine sediments can easily deposit by flocculation. With the SOBEK model it was possible to reconstruct the areas were say a decade ago strong sedimentation occurred. As an indicative value a sedimentation rate of in between 0.5 m and 1 m per year was found when the Pan Hlaing Sluice would not be implemented. Hence, the sluice can be considered essential not only for improving water quality during the dry season but also for reducing the sedimentation by blocking of the salt water inflow into the Pan Hlaing River.

SOBEK simulations (Chapter 7 of the PHRIDP report)

The original SOBEK model of the ID was adapted by the consultants, in close co-operation with the ID, for usage as the PHRIDP model. The adaptations included amongst others: extension of the model, introduction of updated and additional cross-sections, addition of a tidal boundary condition at Yangon (based on harmonics), discharges a the upper inflow boundaries, introduction of salinity and introduction of sediment into the model.

The tidal boundary could rather well reproduced by the harmonics, however lateral discharges (positive for drainage and negative for irrigation) had to be roughly assessed. This latter adaptations were specifically done for obtaining drainage and irrigation simulations. The simulations show that the irrigation need, set at nearly 27 m^3/s, can in principle be facilitated by the Pan Hlaing Sluice, when placed at the mouth of the river. The drainage simulations show that maximum water levels in the river may go down by 2 m (downstream side) to 1 m (upstream side) during severe rainstorms, taking the rainfall data of August 2012 as a reference. It is also anticipated however, that the sluice may have to be extended in future when drainage requirements increase.

Agriculture and irrigation (Chapter 8 of the PHRIDP report)

In this Chapter the more vision is developed on irrigation projections, potentials, water quality and water balances. The earlier mentioned figure of an irrigation extraction of nearly 27 m^3/s has been substantiated in this Chapter. In addition the water demand for the anticipated town extension (population 2 million) can be set at about 3 m^3/s. Hence, it can be seen that optimization of the largest consumer (agriculture) is of utmost importance. Information on soil characteristics and cropping patterns is given in Section 8.1.

Factsheets (Chapter 9)

Central approach for the Pan Hlaing Sluice project is learning-by-doing, with the aim of capacity building. As a practical approach here the development of a toolbox of factsheets has been chosen, especially to be used in the curricula of Yangon Technical University (YTU) and

Myanmar Maritime University (MMU). Moreover the factsheets can be made available for other interested parties. To this development, intensive student sessions have been undertaken.

Integrated development plan (Chapter 10)

The findings and outcomes of the study have been condensed in an integrated development plan in Chapter 10. A major synthesis was obtained from translating the stakeholder requirements as tangible targets for the Pan Hlaing Sluice, i.e. the sluice design and location. Along these lines a qualitative evaluation of three potential locations was developed (Table 10.1):

- Sluice location 1: near the river mouth;
- Sluice location 2: at the site of the temporary cofferdam;
- Sluice location 3: at the Pan Hlaing Bridge site.

From the evaluation matrix, location 1 near the river mouth was considered best.

Recommendations (Chapter 11)

The PHRIDP study has been completed with a Chapter on recommendations. These refer to:

a) Sluice location
b) Integrated design
c) Additional studies
d) Additional investigations
e) Sluices, operation and maintenance
f) Mezali Sluice

- As the most suitable location, location 1 is recommended, especially for water storage. However, as regards the large discharge of untreated industrial water and the future reservoir like storage during the dry season, this water should be treated or diverted to the Hlaing River.
- Within integrated design close interaction should take place with the stakeholders of the real estate (north of the river mouth) as well as with the YCDC for the new city extension (south of the river mouth).
- Additional studies are recommended, especially referring to a greater river system between Ayeyarwady River and Yangon River. This recommendation specifically addresses the implications of other water usage of Pan Hlaing River on the Kokkowa river (e.g. siltation, salt intrusion changes), within a wider context of a Greater Yangon Water Management Master Plan. It is acknowledged that this is beyond the immediate needs and scope of the present project. Although not mentioned in the report, we note that such a wider study, including bathymetric and hydrometeo monitoring and surveying, could help future operational management of the weir. Other items for such a Master Planning would be: urban planning, water quality studies and sustainable growth/planning.
- Additional investigations are recommended for measurements of water flow, water levels, sedimentation and salinity, amongst others in order to optimally operate the Pan Hlaing Sluice. We note that water quality is not mentioned here, but should be addressed explicitly, as this may impose flushing requirements.
- Obviously, additional investigations will be required for detailed design of the Pan Hlaing Sluice, such as: geotechnical, topographical and bathymetrical investigations. We note here that additional hydraulic studies will be needed to design sluice gate control works (e.g. closing and opening speeds).
- The item of sluices, operation and maintenance focuses on the recommendation to operate the Mezali sluice from one place and to have similar sluice structures. This is also emphasized under recommendation f), but now we know that the Mezali sluice has already

been built, due to urgency reasons, without taking into account the future detailed design of the Pan Hlaing Sluice.

A5.2 Appraisal of the Feasibility Study report

A major part of the Final Feasibility Study report for the Pan Hlaing Sluice, has been taken from the PHRIDP report, so our appraisal will focus on newly reported items. Actually new, when compared with the PHRIDP report are the sections that elaborate on the sketch design of the sluice:

- Section 5.4, dealing with the sluice as a potential landmark;
- Section 6.3 and 6.4, dealing with further elaborated design criteria and with the considerations for the width of the sluice as well as for the invert (= sill) level, with a more precise location (for Location 1), with the type of foundation, gate types and evaluation, with seepage prevention and with erosion protection (including stilling basin design).
- Chapter 7, strongly pinpointing at the necessity to avoid the industrial waste water to be drained towards the Pan Hlaing River. As a temporary solution a collector pipe is suggested to pump the waste water towards the Hlaing River, however in the near future to be replaced by a waste water treatment plant.
- Chapter 8, in which the construction phasing is schematically indicated. The construction could start by building an abutment dike, subsequently a building pit for the sluice can be realized, after completion of the sluice, the building pit can be removed and the northern abutment dike can be built. The suggested construction phasing is motivated for a number of reasons.
- Chapter 9 gives a cost estimate with a large band width due to the many uncertainties encountered: 50 M US$ +/- 40 %.
- Chapter 10 presents conclusions and recommendations which are sluice related and looks forward towards further design steps. In addition, recommendations are being given that relate to the (farther) future, for which the capacity of the sluice may have to be increased. Reasons for such anticipation are: further urban expansion, climate change (higher tidal levels, increase rainfall intensities), potential runoff surface increase, potential need for flushing for removal of silt deposits in the river. The sluice location near the mouth is considered favourable to cope with such changes, as well as space to be able to build additional sluice sections when required. Moreover it is advised to keep sufficient space along the Pan Hlaing River to act as retention areas in case of extreme events. Finally it is advised to install automatic water level monitoring equipment both upstream and downstream of Mezali Sluice 2 and of Pan Hlaing Sluice, in order to secure and improve the operational management of the sluices.
- Chapter 11 reports on considerations for the next design phase. However, this Chapter proceeds with detailed discussions on the tidal boundary condition, water levels at Mezali and salt intrusion, followed by model uncertainties and impact. This Chapter seems somehow disordered within the context of the subject of Chapter 11.

In the Annex the SOBEK model is being described, however no new information is given compared to the PHRIDP report.