Government of the People's Republic of Bangladesh
Ministry of Local Government, Rural Development and Cooperatives
Local Government Division
Local Government Engineering Department

Guidelines for
Small Scale Water Resources Development Project

G4 Feasibility Study of Subproject

November 2017

TABLE OF CONTENTS

Document Architecture of the New Sets of Guidelines for SSWRD Project

[Small Scale Water Resources Development (SSWRD) means, from physical points of view, implementing appropriate water management subprojects of small sizes, not exceeding 1000 hectare benefit area by the current definition, to resolve existing water management constraints to agriculture that in turn enhance rural employment leading to reduction of rural poverty. Implementation of SSWR subprojects involve long process from proposal of a subproject from Local Government institutions (Union Parishad and Upazila Parishad) to its final selection, study of feasibility from different considerations (social, environmental, technical, economical), preparing detailed design and costing, constructing required physical works to standard quality and finally its operation and maintenance by its beneficiaries. The process has multiple facets too. It needs to be comprehensively beneficiaries' and other stakeholders' participatory, acceptable to people of widely varying social and socio-economic conditions, friendly to the surrounding environment, etc. Thus, Guidelines for SSWR Development is, of necessity, complex.

The long and complex process has been divided into major distinguishable steps and separate Guidelines for works and activities involved in those major steps have been developed. Environmental study applies to the subproject as whole and is of different nature. So, Guidelines for Environmental Assessment is made a separate document. Following this principle, the Ten (10) Guidelines with Alpha-numeric ID Numbers and Names as below constitute the Documentation of Guidelines for SSWR Development.

This list will appear in all the individual Guideline Documents with highlight of the current Document name for the user to refer when necessary]

The List of New Sets of Guidelines for SSWRD Project

G1	Policy and Development Process
G2	Identification of Subprojects
G3	Participatory Rural Appraisal of Subprojects
G4	Feasibility Study of Subprojects
G5	Environmental Assessment of Subprojects
G6	Detailed Design of Subproject Structures
G7	Construction of Subproject Structures
G8	Operation and Maintenance
G9	Monitoring and Evaluation
G10	Integrated Rural Development Plan between SSWR and Rural Road/Market

AMENDMENT AND UPGRADATION RECORDS

This document "**Guidelines for SSWR Development: G4 Feasibility Study of Subprojects"** has been issued following amendments and up-gradations as outlined below:

Revision	Description	Date
	Guidelines for the Participatory Process in Small-scale Water Resources Development, initially developed for ADB-supported SSWRDSP (1995-2002) guided feasibility study and design of SSWR subprojects of the two ADB-supported Projects - SSWRDSP (1995-2002) and SSWRDSP-2 (2002-2009).	April 1999 March 2006
A	The above Guidelines document of ADB Project was updated and adapted as "Planning and Design Guidelines: Methodology and Common Subproject Components (updated 2009)" for feasibility study and design of the JICA-supported SSWRDP (2009-20015). The ADB-supported PSSWRDSP (2010-2017) also used a similar Guidelines document. .	May 2009
B	SSWR Development Strategy, Processes and Support (draft) – proposed introduction of variations to development process for three categories of subprojects : (i) without water flow regulation; (ii) with water flow regulation; and (iii) performance enhancement.	December 2013
C	The SSWR Development Strategy, Processes and Support (draft) document was revised and upgraded following consultation with relevant professional specialists and the Detailed Subproject Development Process was firmed up in a series of meetings in IWRM Unit chaired by Addl CE (IWRM), LGED in Nov-Dec, 2014. Provisions of the upgraded Subproject Development Process were used in the ongoing JICA-assisted SSWRDP (2009-2015) but the document Planning and Design Guidelines (2009) was not updated for being towards the end of the project period.	January 2015
D	This "**Guidelines for SSWR Development: G4 Feasibility Study of Subprojects**" is the ***Fourth*** Document of the Series of Guidelines for SSWR Development finalized and approved by a Working Group of LGED Professionals with proven experience in SSWR development with assistance from Specialist WR Development Consultants under a JICA-LGED Technical Co-operation Project. The Document builds on the guidelines for preparing feasibility study contained in the "Subproject Planning and Design Guidelines (May 2009)" (excluding the *Detail Engineering Design* part for which a separate document has been prepared) and the "SSWR Development Strategy, Processes and Support (revised draft, January 2015)" together with incorporation of improved methods and techniques and lessons learned over the time.	August 2017

GLOSSARY

Aman	Rice grown during the wet season (Kharif), and harvested late (Nov-December). Yields: (i) Broadcast, deep water 1.5t/ha; (ii) Transplanted, local variety 2.2t/ha; (iii) Transplanted, high yielding variety, 3.25t/ha
Aus	Rice grown during the wet season (Kharif), and harvested early (July-August). Yields: (i) Broadcast 1.25t/ha; (ii) Transplanted, high yielding variety, 2.5t/ha
Beel	Saucer shaped low-lying area with pond of static water as opposed to moving water in rivers and canals.
Boro	Irrigated rice grown in the early dry season (Rabi). Transplanted in December-January and harvested in April-May. Yield: Transplanted, high yielding variety, 4.25t/ha
District	Second administrative unit of the government comprising 6-9 Upazilas. There are 64 districts in Bangladesh.
Haor	Haor is a wetland ecosystem in the north eastern part of Bangladesh. Physically a bowl or saucer shaped shallow depression, also known as a back-swamp
Integrated Water Resources Management Unit	Unit comprising two sections: (i) planning & design, and (ii) operation & maintenance, with a mandate to guide LGED's activities in the water sector with specific responsibility to assist in enunciation of policies, formulation of strategies and plans, preparation of new projects, inter-agency coordination and with external agencies, undertake studies and to provide long term support to the completed projects
Khal	Natural or man-made water channel (canal)
Kharif	Wet (monsoon) season
Local Stakeholder	Local Stakeholders are inhabitants of an area directly or indirectly affected by water management, be it as beneficiaries or as "project affected people".
Project Affected People	People negatively impacted by investment in water management projects and / or subprojects or by the manner in which water regulating infrastructure is managed.
Project Consultants	Project implementation consultants working with the PMO
Project Management Office	A unit comprising LGED staff appointed to manage implementation of a Project
Rabi	Dry / winter cropping season (November to March)
Stakeholder Groups	Stakeholder groups are collections of individuals who have similar interests concerning water. Among others, such stakeholder groups are men and women, farmers (low, medium low, medium high and high land farmers), fishers, boatmen, landless, elected representatives, LGED employees, BWDB employees, employees of other government departments, contractors, consultants, and development partners.
Union	Subdivision of Upazila and the lowest governance institution in the country.
Union Parishad	Local government institution at Union level. The Union Parishad consists of an elected council & chairman, and is the oldest government institution in Bangladesh
Upazila	Administrative unit, sub-division of District and lowest administrative tier of the government.
Upazila Parishad	2nd tier of local government institution at Upazila. According to the Upazila Parishad Act 2009, Upazila Parishad consists one elected Chairman and two Vice-chairmen, Chairmen of UPs and Mayor of Municipality within each Upazila including representatives from line agencies with an Upazila Nirbhai Officer as the Secretary. The election of the Upazila Parishad was held on 22 January 2009. Upazila Parishad runs the local administration.

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AE	Assistant Engineer
BWDB	Bangladesh Water Development Board
CA	Community Assistant (Project Based – Subproject Level)
CO	Community Organizer
CPO	Community Participation Officer (Project based, District level)
CS	Construction Supervisor (Project Based – Upazila Level)
DAE	Department of Agricultural Extension
DDM	Detailed Design Meeting
DLIAPEC	District Level Inter-Agency Project Evaluation Committee
DOC	Department of Cooperatives
DOF	Department of Fisheries
DWRA	District Water Resources Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Mitigation Plan
FMC	First Management Committee (of WMCA)
FSDD	Feasibility Study and Detailed Design
GoB	Government of Bangladesh
IEE	Initial Environmental Examination
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
ICM	Integrated Crop Management
IWRMU	Integrated Water Resources Management Unit (of LGED)
LCS	Labour Contracting Society
LGED	Local Government Engineering Department
MC	Management Committee (of WMCA)
MEP	Member Education Program
MIS	Management Information System
MLGRDC	Ministry of Local Government, Rural Development and Cooperatives
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
PAP	Project Affected Person
PE	Performance Enhancement
PEA	Performance Enhancement Appraisal
PM	Planning Meeting
PMO	Project Management Office
PRA	Participatory Rural Appraisal
QC	Quality Control
SAE	Sub-Assistant Engineer
SAPROF	Special Assistance for Project Formulation
SP	Subproject
SSWR	Small Scale Water Resources
SSW-1	SSWR Development Project Phase I (ADB), 1996-2002
SSW-2	SSWR Development Project Phase II (ADB), 2002-2009
SSW-3	SSWR Development Project (JBIC), 2009-2016
SSW-4	Participatory SSWR Project (ADB) 2010-2017
TA	Technical Assistance
UDCC	Union Development Coordination Committee
UE	Upazila Engineer
UP	Union Parishad (local council)
UzP	Upazila Parishad
WMCA	Water Management Cooperative Association
XEN	Executive Engineer (usually used in LGED)

Farm, Land and Subproject Categories

FARM CATEGORIES

Land Holding		Farm Category
(ac)	(ha)	
<0.51	< 0.21	Landless
0.51 – 1.00	0.21 - 0.40	Marginal Farmer
1.01 – 2.49	0.41 – 1.00	Small Farmer
2.50 – 7.49	1.01 – 3.03	Medium Farmer
>7.50	>3.03	Large Farmer

LAND CATEGORIES

Depth of Average Monsoon Flooding		Land Category
(m)	(ft)	
<0.3	<1.0	Highland
0.3-0.9	1.0-3.0	Medium Highland
0.9-1.8	3.0-5.9	Medium Lowland
>1.8	>5.9	Lowland

SUBPROJECT CATEGORIES AND TYPES WITH USUAL WORKS AND OBJECTIVES

Category		Type		Typical Works with Objectives
I	Simple (without Regulation of Water Flow)	DR	Drainage	Re-excavate drainage *khals* to increase capacity of drainage systems to benefit agriculture as well as fisheries and local navigation
		TI	Tidal Irrigation	Re-excavate existing *khals* to enhance tidal flux (volume and propagation) in the *khals* in dry season to benefit irrigated agriculture in fresh water tidal areas as well as fisheries and local navigation (also increases drainage capacity)
II	Complex (with Regulation of Water Flow using gated or other kind of structures)	FM	Flood Management	Rehabilitate and construct embankments and/or sluices/regulators to reduce extent and duration of flooding of farmland inside the subproject
		FMD	Flood Management and Drainage	Rehabilitate and construct embankments, sluices/ regulators and re-excavate *khals* to reduce extent and duration of flooding of farmland and increase drainage capacity of khal system of the subproject
		FMDTI	Flood Management, Drainage and Tidal Irrigation	Rehabilitate and construct embankments, sluices/ regulators and re-excavate *khals* to reduce extent and duration of flooding of farmland, increase drainage capacity and tidal flow capacity of khal system of the subproject. Sluices/regulators of these subprojects will have arrangements of automatic flow of drainage and tidal inflow at the gates.
		WC	Water Conservation	Develop water retention capacity of existing *haors*, *beels* and *khals* to increase availability of surface water for irrigation in dry season by installing gated water retention structures (also *Rubber Dams* at appropriate sites) and by re-excavating *khals* and suitable water bodies
		FMDWC	Flood Management, Drainage and Water Conservation	Combination of works involved in FMD and WC type of subprojects outlined above
		CAD	Command Area Development	Development of existing irrigation schemes by providing better water distribution systems over the command area and, as agreed, pumping facilities. Works may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump

Category		Type		Typical Works with Objectives
				house, etc.
		DRCAD	Drainage and Command Area Development	Development of existing irrigation schemes by providing better water distribution systems including drainage improvement measures for the command area and, as may be agreed, pumping facilities. Works may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump house, headwater tanks, regulators/sluices in drainage khals, etc..
		FMDCAD	Flood Management, Drainage and Command Area Development	Development of existing irrigation schemes by providing better water distribution systems together with flood management and drainage improvement facilities forr the command area and, as may be agreed, pumping facilities. Works may include: improved canal network, lining of canals, installation of buried pipelines, installation of control structures, construction of pump house, headwater tanks, etc and construction / rehabilitation of embankments, sluices /regulators in drainage khals, etc..
III	Performance Enhancement	Any Type of Existing Subprojects		Any of the above described works for existing (developed and handed over) subprojects for which additional works are desirable to consolidate planed benefits / result in additional benefits

I. INTRODUCTION

1.1 Background

1. This Document ***"G4 Feasibility Study of Subprojects"***, the *fourth* document in the series that describe the Guidelines for SSWR Development, outlines the procedure, methodology and criteria of feasibility analyses including environmental examination and assessment and institutionalization of local stakeholders' participation in SSWRD subprojects. It builds on previous versions of the document but incorporates up-to-date experiences and lessons learned from implementation of four SSWRD projects over the last 20 years.

2. The document is meant to address the following principal objectives in feasibility study of SSWRD subprojects:

(1) Document the feasibility study and IEE/EIA process of each subproject comprehensively;
(2) Increase efficiency of conducting feasibility study of a large number of subprojects by streamlining the methodology of use of all the system elements; and
(3) Produce feasibility study and IEE/EIA reports in standardized useable sizes.

3. Appraisal of a SSWRD subproject following this guidelines will be documented by the two outputs as below: :

a. ***Feasibility Study and IEE/EIA Report:*** This report will be distributed to the respective LGED District Executive Engineers and, as may be necessary to Development Partner agencies. The report follows a standardized format containing analyses in *five disciplines* - Engineering, Agriculture, Fisheries, Socio-economic, and Environment in separate *Sections* supported by an ***Engineering Annex*** and the required number of ***Exhibits*** containing detail technical analyses and the primary and secondary data collected.

b. ***Two Annexes:*** The PRA and Environmental Assessment are two separate studies to be done for the subproject following Guidelines ***G3: Participatory Rural Appraisal of Subprojects*** and ***G5: Environmental Assessment of Subprojects*** respectively. Feasibility analyses of the subproject will draw upon these studies and make references to them and therefore Reports of these two studies will form two ***Annexes*** of the Feasibility Report and will be attached to it.

4. Participatory Rural Appraisal (PRA) of a reconnaissance "passed" subproject, a brief farmer and local stakeholder level study, will be done separately by the contracted FSDD firm or, if specifically required by the related development partner agency, by an independent firm/NGO. PRA of every individual subproject will be done following a separate Guidelines Document **G3: Participatory Rural Appraisal of Subprojects**. The PRA study will provide comprehensive data and information on social and socio-economic aspects of the subproject along with decision on whether the subproject has social acceptability and beneficiaries are willing to form a beneficiaries' participatory association and bear responsibility of O&M of the subproject including cost sharing.

5. The PRA though conducted as a prerequisite as to whether or not the subproject will be taken up for an extensive feasibility study, the feasibility study will use data and information, particularly on social and socio-economic aspects, from the PRA study and

often make reference to it for details. The PRA report will therefore be attached to the FS Report as ***Annex-II***.

6. The SSWRD subprojects involve rehabilitation and upgrading of existing water management systems of local dimensions (subproject areas are less than 1000 ha) meant to remove or mitigate existing constraints to agricultural production. These subprojects are judged in the 'B Category' (Orange) according to Bangladesh Environment Conservation Rules, 1997. For these subprojects, IEE would suffice in most cases. However, in subprojects where IEE will indicate a significant residual environmental impact, a detail EIA will be conducted.

7. Environmental Assessments of every individual SSWRD subproject will be done following a separate Guidelines Document **G5: Environmental Assessment of Subprojects**. This feasibility study guidelines will discuss environmental analysis of the subproject – IEE/EIA including EMP to mitigate any residual impact, in ***Section 3.7*** by drawing upon the above Environmental Assessment study and make reference to it for detail information. The Environmental Assessment Report of the subproject will be attached to the FS Report as ***Annex-III***.

II. PRE-FEASIBILITY STUDY AND DLIAPEC CLEARANCE

2.1 Background

8. The flow chart of the subproject development process show that the formal process for institutionalization of beneficiaries' participation starts only after the subproject is cleared at the district level by a statutory District Level Inter-Agency Project Evaluation Committee (DLIAPEC) regarding duplication or overlapping with projects/programs of other agencies. However, the Executive Engineer, LGED can present the subproject to the DLIAPEC only when the subproject has taken a concrete shape in respect of location and area, development concept, planning of physical infrastructure/interventions, economic and other viability indices, etc. Accordingly, the previous development processes required to hold the DLIAPEC review of the subproject with the final Feasibility Report completed.

9. But this entailed a too short time for the WMCA to be formed, registered and made capable to sign Implementation Agreement (IA) to start the tendering process though preparation of detail design and drawings were completed quite earlier. The tendering process had to wait until WMCA could sign the IA. This was resulting in a host of works in the last year of the project, sometimes necessitating extension of project period.

10. On the other hand, a relatively longer period – the time when feasibility study of the subproject was being done, remained without any activity for WMCA development. It was noted that if the DLIAPEC review can be held earlier – sometime at the start of feasibility study activities, the entire time required for feasibility study can be available for WMCA development activities i.e. the institutional process will get a desired longer time . In fact, the PMO-Project Consultants of the last two SSWR projects (JICA-1 and ADB-3) had used this slot by holding the DLIAPEC review with an interim report called *Planning Concept Report.*

11. The subproject development process adopted in this *SSWR Development Guidelines Documentation* has therefore included conducting a quick prefeasibility analysis of the subproject and prepare a brief but comprehensive Pre-Feasibility Study Report to hold the DLIAPEC review before commencing the main feasibility study that takes time for field survey, detailed data collection, conducting analyses of the different Annexes and synthesizing the Feasibility Report.

2.2 Pre-Feasibility Study and Report

12. **Step 8(a) - Field Investigation by FS Consultants:** With a subproject "passing" in PRA, the contracted FSDD firm will undertake an exhaustive field investigation of the subproject by a multidisciplinary consultant team of five specialists (water resources engineer (team leader), agriculturist, fisheries specialist, sociologist and environmentalist). More details on preparatory and on-field activities of the multidisciplinary team are given in the appended ***Exhibit G4-A***.

13. The team will be provided with copies of Form 1, Form 2 and Form 3 of the subproject identification stage along with the Subproject Map prepared during pre-screening that will give them the basic problem and the nature of relief/remedy that local stakeholders have desired and the considerations/criteria on which IWRMU-PMO has allowed the subproject to proceed. The Reconnaissance Report including the maps prepared by the reconnaissance team and PRA Report will not be provided to the team at this stage so that the team can develop their own independent observations and opinions. Duration of the field investigation visit may be 2-4 days depending on size and complexity of the subproject.

14. Local LGED staff – UE/SAE from Upazila Engineer's Office and/or Assistant Engineer/Community Participation Officer (project staff) from District LGED Office will participate in the field visit program as observer from LGED and facilitate the activities.

15. The multidisciplinary team will visit the subproject boundary, talk to local people and justify the boundary including any alteration, both inclusion and exclusion, they consider appropriate. The team will visit significant locations in the subproject area to understand and assess the problems that is to be addressed with all its causes and consequences, observe and take note of the conditions of all relevant physical features and interventions proposed by local stakeholders (Form 1 and Form 2), note the appropriateness and adequacy of the interventions proposed and discuss with local people about functioning of the interventions and any alternatives, etc the team considers better. Through this visit using the Subproject Map, the team will develop an on-field planning of interventions and infrastructures that will be necessary to address problems of the subproject area. The team will also make a comprehensive list of all physical works required in the subproject with tentative quantities – number, lengths and tentative sections for required khal re-excavations; number, lengths, tentative level and sections of embankments; number, location, type and size (number of vents) of hydraulic and other kind of structures.

16. The agriculture specialist in the field investigation team during visit to different locations will discuss with local people about the impact of subproject on agriculture and assess possible annual benefit by noting – the area where crop suffers damage due to the water management problem (mark the area on the map with the help of information like village/mouza and the crop field visible on the imagery map), frequency of crop damage and extent of damage corresponding to different frequencies, crops grown and damage by crops with usual yields, cost of cultivation, etc. All the collected data should collate to a reasonable estimate of the average annual agricultural benefit of the subproject.

17. The fisheries and other specialists in the field investigation team will likewise visit the subproject area at the different points, talk to people, develop their understanding of the problem at the subproject and collect relevant data/information to assess impacts and viability of the subproject.

18. The field investigation team will have, after completion of field works, a debriefing discussion with the Executive Engineer, LGED and other District level project staff about the overall activities and findings at the subproject site.

19. **Index Map, Physical Works and Cost of Subproject:** After the field investigation and preliminary data collection, the team will consolidate planning of the subproject and prepare a subproject ***Index Map in Google Imagery*** showing all physical features – roads, khals, rivers, water bodies, homesteads, crop fields, etc based on the previous *Subproject Map* and all the planned subproject infrastructure – excavation / re-excavation of khals, re-construction / construction of embankments, regulators / sluices / water retention structures, other structures (if any) as per the detail field investigation.

20. Land elevation characteristics of subproject areas are obtained from the 4 inch to 1 mile (1:15,840) Water Development Maps (1965) that are available for nearly the whole country with contours of 1.00 ft (300mm) intervals. As these maps are quite old, alignments/locations of rivers, khals and water bodies differ from the present situation as given by Google Imagery. Elevations of low lands also have undergone changes. However, ***another Index Map*** of the subproject is to be prepared using the 4 inch to 1 mile scale contour maps by transferring the subproject boundary and alignments of khals and rivers from the Google Image based Index Map. The area-elevation-storage characteristics of the subproject area are established by measuring areas under various elevation contours using this **Index Map**. As accurate digital elevation models (DEM) will become readily available, land types (by flooding depths) would be quickly determined without the need for field topographic survey.

21. The list of all planned works is finalized with their tentative quantities and costs. Thus the total subproject cost based on a preliminary estimate will be obtained. The approximate annual O&M cost can also be estimated using a standard basis (the current basis is 1.5% of cost of structures and 3% of the cost of earthworks). A copy of the Index Map will be made in A1 size for presentation in the Planning Meeting.

22. **Benefit and Socio-Environmental Impact:** The only tangible benefit of SSWRD subprojects is from agriculture. The Agriculturist of the FS field investigation team will collate and consolidate data and information collected from the field investigation and asses the tentative net lands that will be benefitted due to the subproject by nature of the benefit (improved drainage, protected from flood, supplied with irrigation water) and name of the benefitted crops with tentative areas, production and net financial returns from them which will sum up to the total benefit of the subproject. Location of the net benefit area will be shown in the subproject Index Map.

23. SSWRD subprojects generally reduce open water capture fisheries. However, improved water management and added support and attention to the fisheries sector activities, particularly in culture fisheries, have impacted an increased fisheries production in many subprojects. The Fisheries Specialist of the field investigation team will, considering the features and conditions at the subproject and the interventions planned for water management, analyze data and information collected from the field visit and come to a pragmatic estimate of the subproject's impact on fisheries, either positive or negative.

24. The Sociologist and Environmentalist of the field investigation team, likewise, will analyze field conditions and all the data/information obtained from field by observations and discussions with local people and consolidate the issues with respective responses / impacts. There will, however, be summary observations on the social acceptance and environmental viability of the subproject.

25. **Draft Pre-Feasibility Study Report:** The FS Consultants and Specialists participating in the field investigation will discuss, after their return from field, their investigation and observations with PMO-Project Consultants and conduct the follow up subproject planning, cost and benefit assessment and viability analysis activities (paragraphs 18-21) in close consultation with the Project Consultants as part of the quality check measures. By collating and consolidating all these outputs of the field investigation, the FS Consultants will prepare a draft Prefeasibility Report for use in the Planning Meeting.

26. The Prefeasibility Report will be concise and follow the contents as outlined in ***Exhibit G4-B*** appended to this document.

27. **Step 8(b) - Planning Meeting:** The engineering works planned for the subproject have largely been decided through discussions with local people in previous steps – proposal, reconnaissance, PRA and the field investigation by the FS Consultants. However, the subproject planning is to be discussed with beneficiaries representing the whole subproject area and be agreed upon, if necessary with modifications emanating from the meeting. This is done in a Planning Meeting of the subproject participated by a wide section of beneficiaries and other local stakeholders.

28. The Planning Meetings will be organized and held by the District Executive Engineer, LGED through a wide publicity in the subproject area. Project staff at District and Upazila will assist LGED staff in making the meetings successful. The venue of the meetings will be at a place nearly central to the subproject area and having good access from all areas of the subproject. Date and time of the meetings should also be decided considering scope of rural people to attend – excluding big market days, avoiding peak work times of days, etc.

29. The organizers will take special efforts to ensure participants from all parts of the subproject area, from all groups of stakeholders – landless and small farmers to big farmers, communities of professional fishermen and boatmen, leaders and respected persons from all involved villages, etc.

30. The Executive Engineer, LGED of the District will attend the Planning Meetings as these are public meetings called in his name. His presence will enhance participation and effectiveness of the meetings. Besides, Planning Meetings will be attended by all District and Upazila level LGED-staff related with water sector activities, all District and Upazila level project staff, and representatives from IWRM Unit and PMO-Project Consultants.

31. As Planning Meetings are open general public meetings, a respected person present will be made President of the meeting. He will preside over the meeting and sign its minutes. The FS Consultants will engage two eligible persons to prepare participant's list, keep records of the meeting and prepare minutes of the meeting. The Executive Engineer, LGED and PMO-Project Consultant representative will facilitate the meeting.

32. The FS Consultants will present the subproject planning in the meeting using a big (A1) size Index Map showing all the proposed works of the subproject. He will describe the works planned with their locations and functions with the expected benefit from them. All participants will be requested to participate in constructive review of the subproject planning. Alternatives and other suggestions emanating from the participants will be duly discussed and if agreed unanimously will be accepted.

33. Besides engineering planning of the physical works of the subproject, The Planning Meeting will also discuss the project requirements that (i) the beneficiaries from all over the subproject area will form a WMCA under the Co-operative Law by being member of it and undertake responsibility of operation, maintenance and management of the subproject through an elected Management Committee of the WMCA after the subproject is constructed, and (ii) the beneficiaries together will make an upfront contribution (currently equal to 1.5% of the cost of structures and 3% of the cost of earthworks) to the O&M fund of the subproject as a pre-condition for commencing construction works. The collected fund will be kept as fixed deposit in a Bank under joint signature of the WMCA Chairman and Secretary and the Executive Engineer of LGED. There will be a separate operating O&M account of the WMCA where the profit from the Fixed Deposit Account will be transferred and new collected O&M fund will be deposited. All costs of O&M activities will be paid through this operating O&M account. The main fixed deposit fund will remain in fixed deposit continuously. The meeting needs to have a unanimous support to the two issues.

34. At the end of the meeting, the summarized decisions of the meeting will be read out to the participants, incorporated in the minutes of the meeting and signed and issued by the President of the Planning Meeting.

35. **Step 8(c)- Pre-feasibility Study Report:** After the beneficiaries have agreed with the subproject planning in the Planning Meeting, the FS Consultants will update the subproject Index Map and finalize the Prefeasibility Report in consultation with the Project Consultants by incorporating modifications, if any, emanating from the Planning Meeting. The Minutes of the Planning Meeting will be annexed to the Prefeasibility Report.

2.3 DLIAPEC Clearance

36. **Step 9- DLIAPEC Clearance:** As the FS firm submits final Prefeasibility Report, the PMO will send it to the District Executive Engineer, LGED with instruction to hold the DLIAPEC meeting on the subproject. The Executive Engineer will present and explain the subproject plan in the meeting, request the members to examine if there is any duplication or

overlapping of the subproject with projects and programs of their Departments/Agencies and ask for clearance of the subproject for implementation. The DLIAPEC will discuss the subproject and accord the clearance if no overlapping/duplication is noted. If however any duplication/overlapping is found, the meeting will suggest remedial measures, include it in the minutes and give a clearance conditional to the remedial measure. The FS Consultant will revise the subproject planning to incorporate the remedial suggestion. The matter may be resolved through bilateral discussion between the field level officials of the concerned departments and the District Executive Engineer, LGED and/or PMO-Project Consultants and the concerned Department with the revised subproject plan or a second DLIAPEC meeting may be held.

III. FEASIBILITY STUDY

3.1 The Study Components

37. The objective of a feasibility study is to assess that the proposed subproject is technically, economically, socially and environmentally viable. In SSWRD subprojects, this is done through analyses under five component disciplines – **Engineering, Agriculture, Fisheries, Social** and **Environmental.**

38. The procedures of analyses under the respective disciplines including required data and criteria to be followed are described in respective subheads below. These detail analyses and the expected changes following the subproject intervention will be summarized in the component wise ***Annexes*** that will be attached to the feasibility report.

3.2 Engineering Analysis

3.2.1 Introduction

39. The purpose of engineering analysis is to establish the optimal physical interventions needed to support the subproject development concept in general, and to ascertain hydrological changes needed within the subproject area to improve conditions for agricultural production. This can be achieved only when the analysis are based on latest relevant data and information.

40. The engineering analysis should be carried out for all subprojects following a standard general format. The main feasibility report of subprojects will contain general information with salient data/information and justification of the proposed development works summarized from analyses and results thereof from the attached ***Annexes.***

41. Of the usual subprojects implemented under SSWRD projects, CAD subprojects are of uniquely different type – characteristically different from other types (DR, TI, FM, WC) of subprojects. For example, the above four types of subprojects are related to pre-monsoon and monsoon season water regimes i.e. flooding and drainage and therefore design parameters and criteria for these subprojects focus on issues like maximum rainfall, drainage rate, extent of crop damage due to submergence in flood water, design of works like khal re-excavation, embankment development, construction of structures in khals/rivers, etc. On the other hand, for CAD subprojects that are fully irrigation subprojects are related with design and development of irrigation system for supply and distribution of water for irrigation of crops in the dry season. Accordingly, Engineering Annexes of the two subproject groups are made separate:

- **Annex G4-IA: Engineering Annex** for the subprojects (Dr, TI, FMD, WC) where analyses relate to pre-monsoon and monsoon water regimes; and
- **Annex G4-IB: Engineering Annex (CAD)** for CAD subprojects where analyses relate to assessment of irrigation water requirement and irrigation system design and development.

42. The Engineering Annexes will generally provide the following information:

Figure 1: **Index Map** of subprojects showing subproject boundaries, khals, beels, existing and proposed infrastructure and ground level contours converted to meter units from contours in feet shown on 4 inch to 1 mile topographic maps. Index Maps are prepared by using existing reference maps in which infrastructure planned under the subproject and, when possible, their impacts are shown. The basic

reference map for this is the 4 inch to 1 mile topographic map available for the whole country. But the maps are very old - surveyed and prepared during late1950s to mid 1960s and therefore courses of rivers and khals and also alignment of roads, etc have undergone significant changes. Many smaller khals and water bodies have lost their existence and some new have developed. Regarding land elevations, it is believed that changes in high to medium low lands may not be significant while ground levels in lowlands may have increased to some extent due to sedimentation. Under the situation, two Index Maps have been used. The *first* one, identified as ***Figure 1A: Index Map (Google Image)*** is based on Google Image of the subproject area and shows current position of physical features including rivers, khals, water bodies, roads, bridges, homesteads, crop fields, places, etc. The subproject boundary, all planned physical works and impact area boundaries, etc are shown on the Google Image map using AutoCAD. Areas can also be measured from this map. The *second* one, identified as ***Figure 1B: Index Map (Topography)*** is based on the available 4 inch to 1 mile topographic map. Important features of the subproject area like subproject area, catchment area and benefit area boundaries, alignment of rivers, khals, important roads, locations of water bodies are copied on this map from the Google image map. This map will be used mainly to establish the area – elevation – storage relationship of the subproject area by measuring areas under different land elevations following the contour lines within the subproject boundary (refer ***Annex G4-IA, Appendix G4-IA.B, Section B2.A1***)

[For CAD subprojects, additional schematic layouts detailing the irrigation systems (buried pipelines, canals) will be needed]

Figure 2: Base Map of subproject showing location of the subproject in LGED Upazila Base Map of scale 1:50,000. This map presents location of the subproject in a wider surrounding in the Upazila in relation to communication systems, markets, important towns and places, etc.

Figure 3: Regional Map showing location of the subproject in relation with major rivers and khals, main roads and towns, existing BWDB projects (if applicable) and hydrometric stations used in the analysis. As the basis for preparation of Regional Map, topographic map of 1:250,000 scale or hydrological network map may be used.

- Subproject Name and ID Number
- Subproject Location: District; Upazila; Union
- Subproject Areas: catchment area, gross subproject area, net benefited area, command area (for CAD subprojects)
- Area-Elevation-Storage relationship (table and graph)
- Land class analysis (based on flood depth)
- Hydro - Climatic data with statistical analysis
- Hydrological and Hydraulic design of proposed works (khal, embankment, hydraulic structures).
- Basic Drawings of the proposed works

3.2.2 Important Definitions Relevant to SSWRD Subprojects

43. **Water Resources Development Subproject:** A Hydrological Unit within a defined catchment including all existing and planned infrastructure designed for improving water management to improve soil-water relationship for increase of agricultural production.

44. For SSWRD subprojects, net benefited area of a single subproject is limited to 1,000 hectares. SSWRD subprojects must be technically viable, economically feasible, environmentally sound and socially acceptable and must comply with all the specified criteria of the Project under which they are implemented.

45. **Subproject Catchment Area:** Catchment area (also called drainage area, catchment basin or watershed area) is an area enclosed by high elevation points/line that is attributed to a specific low outflow point in the basin through which all rainwater runoff drains out from that basin.

46. A specific subproject catchment is separated from adjacent catchments (basins) by a divide line formed by natural topography of elevated land (successive hills and ridges) or artificial, man-made topography (elevated roads and/or flood embankments, homestead platforms) which can be traced on a topographic map by joining successive highest elevation points in a closed loop starting and ending at the outflow point.

47. Runoff from rain falling over a single catchment drains through the outflow point – a structure or section of a khal or land valley. In the context of SSWR development, two types of catchments can be identified in flat topography areas: dry season catchment and monsoon season catchment. Monsoon season flood may overtop dry season divide boundaries and merge several dry season catchments into one common wet season catchment, which also may have several outflow points or outlets.

48. When demarcating a subproject catchment area, the planner should remember that catchment boundary (divide line) runs through highest points of hills and ridges but it should never cross valleys, land depressions, beels, baors, haors, channels, khals and rivers.

49. In flat topography, there might be channels or small khals connected with other channels periodically draining to the outside of the subproject catchment. These are called double outlet channels with direction of flow depending on water levels in the adjoining basins. In this case the planner should examine the channel in the field, ask local people about direction of flow and water levels at which the flow changes direction. The channel in question should be surveyed. Based on the shape of the profile and the information on water flow direction and time, the planner can decide about the location of the catchment divide line, and leave it as it is or have it closed at the divide line.

50. Subproject Catchment Area is the base parameter used for hydrological and engineering design of subproject infrastructure – size and sections of hydraulic structures and khals.

51. Incorrectly demarcated catchment boundary may lead to design of a subproject, which is not a *hydrological unit* / *sub-unit* and as such covers only a part of or encroaches on neighbouring catchments. This will result in design of a subproject with (i) too small catchment area, or (ii) too large catchment area.

52. Subproject designed with <u>too small catchment area</u> will have undersized channels and structures to convey the actual drainage discharge As a result, post subproject conditions will worsen due to (1) increased drainage congestion and higher internal flood inside the subproject boundary, and (2) accumulation of flood and water logging outside the subproject embankments constructed across the actual subproject basin. Local people will have no choice but to cut embankments at both upstream and downstream end of the subproject, to relieve water accumulated outside embankment and drainage congestion inside the subproject. In such case the undersized structures will be prone to early damage and additional structure(s) will need to be constructed. Also additional embankments along the correct boundary may have to be constructed.

53. Subproject designed with too large catchment area will have excess capacity channels and structures, which results in an accelerated silting of channels due to reduced flow velocity. Also, the subproject construction will require higher capital investment cost and consequently larger beneficiaries' contribution for O&M.

54. **Subproject Gross Benefitted Area:** Gross Benefited Area is the gross area, cultivable and non-cultivable, that is affected by poor drainage, flood or drought, from which these problems should be removed or mitigated after the subproject implementation.

55. Depending on type of subproject, the gross benefited area may comprise a part or whole of the subproject catchment and it includes highland, homesteads, roads and water bodies if present within its boundary. Elevation of the design flood, extent of water logging and elevation or distance to which water can be made available from the storage for irrigation, define the boundary of gross benefitted area.

56. The subproject gross benefited area dominates the *Institutional and Social aspects* of the subproject. It is the base data used for identification of the subproject beneficiaries – farmers whose lands are within the subproject gross benefited area. It is therefore very important that the gross benefited area boundary is correctly demarcated in the field and defined on the Subproject Index Map.

57. The implications of incorrectly demarcated gross benefited area will result in WMCA membership including people who will not be getting any benefit from the subproject but will be demanded to make financial contribution to the subproject.

58. **Subproject Net Benefited Area:** Subproject net benefited area is the area of cultivable land within the subproject gross benefited area. It is calculated by subtracting the area under water bodies, homesteads and infrastructure from the subproject gross benefited area.

59. The subproject net benefited area comprises cultivable land within the subproject that is subjected to improved conditions for agricultural production or land positively affected by the subproject intervention. In other words, all the post-subproject changes in agriculture take place only within the net benefited area.

60. It is the base information used in agricultural planning and determination of the expected subproject benefits.

61. The implications of incorrectly demarcated net benefited area will result in false claims of subproject benefits and/or implementation of non-feasible subprojects.

62. **Subproject Boundary:** Subproject boundary is the outer limit of the area physically affected by the subproject interventions. Depending on land topography, subproject location and subproject type, subproject boundary may be represented by the boundary line of catchment area or by the boundary line of subproject gross benefited area. Usually, in subprojects with sloping topography, catchment boundary coincides with gross benefited area boundary in the lower basin while in the upper basin catchment boundary is farther away outside the gross benefited area boundary.

63. In Flood Management and Drainage subprojects located in coastal area and covering whole polders, and located in floodplains of big rivers with entire subproject area inundated (excluding homesteads), the subproject boundary coincides with the subproject catchment boundary.

64. In Flood Management subprojects located in haor areas of greater Sylhet and Mymensingh Districts with entire subproject area inundated (excluding homesteads) the subproject boundary coincides with the subproject catchment boundary.

65. In Flood Management and Drainage subprojects located in non-tidal area having sloping basins which are flooded only in lower part, subproject boundary coincides with the subproject gross benefited area boundary.

66. In Water Conservation subprojects located in hilly areas or having sloping basins the subproject boundary coincides with the subproject gross benefited area boundary.

67. In Command Area Development subprojects the subproject boundary coincides with the subproject gross benefited area boundary. It may be within a single catchment or it may extend over parts of more than one catchment. This can be so because the most practical alignment of irrigation canals is over divide lines in higher lands.

3.2.3 Engineering Works Required for Different Subprojects

68. The engineering interventions required in a water development subproject depend on the existing problems in the subproject area. The problems, however, may vary according to topography, hydro-geological conditions, and land use of a particular subproject area. SSWRD projects are generally with the primary objective of increasing agricultural production through improved water management but they cut across fisheries sector and therefore are significant for fisheries also.

69. Taking into account the prevailing water management problems and the requirements identified in the course of implementing the previous SSWRD projects, new subprojects for SSWR development are grouped into five basic types which are again divided into two categories. The categories and types of SSWR subprojects with objectives and physical works usually required are listed at the beginning of this Document. However, the categories and types of new subprojects along with the set of physical works that might be needed for the respective type of subprojects are given below for easy reference.

Category-I: Simple Subprojects (without flow regulation)

- ***Drainage improvement:*** Re-excavate drainage channels to increase capacity of drainage systems to benefit agriculture as well as fisheries and local navigation.
- ***Tidal irrigation:*** Re-excavate existing tidal channels to increase availability of dry season tidal fresh water both in quantity and propagation deeper inland for irrigation.

Category-II: Complex Subprojects (with flow regulation)

- ***Flood management:*** Rehabilitate / construct embankments and/or sluices/ regulators to reduce extent and duration of flooding of farmland.
- ***Water conservation:*** Develop water retention capacity of existing haors, beels, and channels to increase availability of irrigation water by installing water retention structures and/or by re-excavating the bed of water bodies and channels.
- ***Command area development:*** Improve existing irrigation schemes by providing better water distribution systems (improved canal network, lining of canals, installing buried concrete or PVC pipelines, installing head water tanks and/or distribution control structures, etc.) to extend irrigated areas.

70. In case of combination of problems and benefits, the five basic types may lead to ten common types of subprojects. Physical works that may be required for the combined type subprojects will also be combination of work requirements of the basic types and can be drawn from the above listing. More details of the characteristic problems and infrastructure

needs of the various types of subprojects are given in ***Exhibit G4-C*** appended to this Document.

71. **Planning of Water Conservation Type:** When planning the water conservation type subproject, it should be considered that the channel in the area normally assumes a role of not only irrigation but also drainage. In case the channel is long, e.g. more than a few kilometres, more than one water retention structures (WRSs) will be necessary. Therefore, in this case firstly the channel should be designed for the drainage, and then the retention level will be determined and followed by the number of WRS taking into consideration of the land availability etc. and then finally the sill level of each WRS will be determined. The basic flow of the consideration is shown as below. Also the comparative observation on WS type subproject planning about two extreme cases is shown below, which suggests careful consideration on pros and cons.

- Step-1: Collect basic data of the subproject area such as land elevation, bed level and alignment of channel.
- Setp-2: Estimate Drainage rate and maximum drainage discharge.
- Setp-3: Determine the channel dimension such as bed level and width of channel taking into consideration of land availability. Deeper bed level will require wider lands than shallow one.
- Step-4: Determine the most appropriate water retention level and structure allocation for WRSs in a comprehensive manner such as economic viability, O&M easiness and environmental changes. Economic comparison should include the cost of land acquisitions.
- Step-5: Sill level of WRS determined in line with channel bed level required for drainage.

Comparative Observation on WC type Subproject Planning

Case	Advantage	Disadvantage
Case-A Retention level: High Nos of WRS: Less	- Cost-effective as the number of structures is less. - O&M may be easier in less number.	- In case retention level is higher than the ground level, the dike to retain water should be newly constructed together with the wider range of lands. - O&M may be harder due to big structure. - The Outlet structure to drain out water from paddy will be also necessary since the dike may impede the drainage. As drainage will be restricted through outlets instead of direct inflow like before, drainage will be delayed. Concentration of drainage through the outlets may eventually develop erosion and small khals causing loss to croplands.
Case-B Retention level: Low Nos of WRS: Many	- Normally no need to newly construct retention dike. - O&M may be easier due to small.	- The construction cost of WRSs may be increased. - O&M may become relatively complexed due to many numbers of structures.

3.2.4 Data Requirement for Engineering Analysis of Subprojects

72. **Preliminary Data for Prefeasibility Study:** Engineering Analysis and for that matter requirement of engineering data commences when the subproject is found to have, by PRA study, popular support and no significant social opposition or environmental adverse impact. Field investigation and prefeasibility analysis are the initial activities and these need mainly secondary data (maps, WL) at the preparatory stage. Primary data collected by the investigating team professionals from field level at the subprojects are approximate but adequate for prefeasibility analysis. Details of these preliminary data requirement and

obtaining them are discussed in ***Section 2.2*** of this Document and the appended ***Exhibit G4-A***.

73. **Detail Data Requirement for Feasibility Analysis:** As the feasibility study investment for the subproject is justified by the prefeasibility study and the DLIAPEC clears the subproject for *no duplication or overlapping with works of other agencies*, the first activity for conducting detail engineering analysis is collection of required primary data from field through engineering survey. Some data (survey and subsoil data of structure sites) will be required only during detail engineering design of structures. These will be collected later after structure sites are finalized. Hydro-meteorological data for relevant stations are collected during prefeasibility study. However, any remaining of these data should be collected at this stage. Following is a listing of data generally required for feasibility level design of proposed physical works of SSWR subprojects.

i. Hydrological Data

- Name and ID Number of WL station(s) that influence water regime
- Daily WL Data (raw or with analysis) of at least current 20 years of above station
- Surveyed max HFL at subproject (from flood marks) highest in 20 years
- Surveyed average Monsoon Flood Level at subproject area

ii. Meteorological Data

- Name and ID Number of nearest weather station
- Name and ID Number of nearest Rainfall station, if different
- Daily Rainfall Data of the above Rainfall /weather stations
- Data of Evaporation, Temperatures, Daylight Hours and Wind Speed (for CAD subprojects)
-

iii. BM and TBM for Survey Works

- Location, ID Number, Distance from subproject and RL (mPWD) of nearest SOB BM Pillar
- Location and RL (mPWD) of established TBM at subproject site for survey of subproject works

iv. Survey Works

- Detail procedures for conducting engineering survey for SSWRD subprojects are given in **Exhibit G4-D** appended to this document
- Surveyed cross-sections at 100 m intervals of existing/new embankments to be re-sectioned/constructed, khals to be re-excavated, irrigation canals to be constructed, buried pipelines to be installed
- Surveyed long sections of the embankments, khals, irrigation canals, buried pipelines those are surveyed.
- Spot GL survey of specified low area of subproject to check possible raised present GL against GL in topographic maps
- Plane Table survey of site of new structure if structure site is exactly known (this survey is needed during detail design and so should be waited until the site is finalized)

v. Survey of Existing Structures to be Modified/Rehabilitated

- Sketch Plan and Elevation Drawings of existing structures that will be modified or rehabilitated with all dimensions

- Surveyed RL of top, invert, upstream and downstream floors and other points as may be considered necessary of the above sketched structures
-

vi. **Subsoil Data (required for Detail Design of structures)**

- Subsoil Investigation for Box Type Sluice/Regulator/WRS (minimum 3 Bore Holes 20 m deep are to be executed; for pipe sluices and culverts subsoil data is not required)
- SPT Values at every 1.5m for full depths of all Bore Holes
- Unconfined Compressive Strength (q_u) of cohesive/clayey soils in the Bore Holes whenever encountered (undisturbed soil samples must be collected from each layer of cohesive/clayey soils encountered and tested in laboratory for q_u)

74. The above is a general data requirement. Depending on the subproject type some data may be omitted and/or other data may need to be included.

3.2.5 Hydrological Analyses Relevant to Subproject Study

a. DR, TI, FMD, WC Subprojects

75. **Area-Elevation-Storage Characteristics of Subprojects:** The relationship between land elevation and corresponding area of land under it and the volume of water that can be held in storage on this land area provides a valuable hydro-topographical tool for analysis of various impacts of the subproject. The relationship is established by using the 4 inch to 1 mile scale (1:15840) topographical maps with land elevation contour lines at 1-foot (0.3 m) intervals. These maps, though old – prepared during late-1950s to mid-1960s, are available for all areas of the country except for Hill Tract areas. Areas between successive contour lines, within the subproject boundary (*refer also to Section 3.2.1, Index Map*) are measured and a cumulative Area vs Elevation data from lowest land elevation to higher is prepared in a tabular form. To this table, a column for volume of water that would be held in storage at the consecutive elevation steps can be added. Thus a tabular data of Area-Elevation-Storage characteristics of the subproject area is established which can be used by the Spreadsheet Design Programs. Also graphs can be plotted using the data for visual analysis and study. Example data and curves of Area-Elevation-Storage relationship is shown in the ***Engineering Annex, Appendix G4-IA.B, Section B2.A1*** for reference.

76. **Design Basin WL and Drainage Rate of Subproject:** Design Drainage Rate is the rate expressed in millimetres per day at which the runoff generated from design storm rainfall over the entire subproject catchment area (may be more than subproject area) has to be drained out so that inundation damage to crops grown in the net benefited area remains within the acceptable limit - up to 5% of the net benefited area. That is to say, as the design storm runoff is drained at a certain drainage rate, the maximum water level in the subproject area should be such that criteria for crop damage is not exceeded i.e. no more than 5% of the benefited area remains submerged for more than three days with depth of water more than 0.3 meter. This water level in the subproject area is termed as the Design Basin Water Level because it satisfies the acceptable crop damage criteria.

77. The design Drainage Rate is determined, to meet the above acceptable crop damage conditions, by applying the design 5-day 10-year storm onto the subproject catchment area (basin) and carrying out a iterative water balance (or flood routing) calculation with a time step of one day. The calculation is carried out using the MS Excel Spreadsheet Program "DRate Analysis" using the design storm rainfall and the basin area-elevation-storage data.

The program calculation is run by typing in a "trial drainage rate value" and observing the "number of days in the column for full damage day". If the number of days is just 3, the trial drainage rate is the Design Drainage Rate and the maximum value in the WL_{Basin} column is the Design Basin Water Level. Example calculation of Drainage Rate and Design Basin WL analysis using the Spreadsheet Program "DRate Analysis" is shown in ***Engineering Annex Appendix G4-IA.B, Section B2.B*** for reference.

78. **Land Types and Changes in Land Types under Subprojects:** Land type or land class as is related to agriculture and, for that matter, to agricultural water management is defined based on flood phase (depth of water) of lands as below:

Highland	F0	0-0.3m depth of water on land
Medium highland	F1	0.3-0.9m depth of water on land
Medium lowland	F2	0.9-1.8m depth of water on land
Lowland	F3	>1.8m depth of water on land

79. Full Flood Management subprojects impact agriculture by lowering water depth in the subproject area such that lands from deeper flood phase changes to shallower flood phase whereby area and cropping of shallow flood phase lands increase. Therefore, assessing amount of land changing flood phase i.e. land type change occurring due to the subproject is an essential analysis in impact assessment of Full Flood Management subprojects. Partial Flood Management subprojects and Drainage Improvement subprojects protect crops from pre-monsoon floods and improves cropping by reducing subproject WL but do not change land types as the impacts do not persist over the whole monsoon season and also on long terms. Water Conservation and CAD subprojects are dry season subprojects having no interference with monsoon waters and so do not make any land type change impact.

80. Spreadsheet Program in MS Excel has been developed that works with the tabulated Area vs Elevation data of a subproject and gives areas of different land types under a given WL in the subproject according to the above flood phase definition. Accordingly, by using pre-subproject and post subproject WLs, two sets of land types are calculated and the difference between post-subproject and pre-subproject land type figures indicate the land type change due to the subproject. Example calculation of land type analysis and change in land types are shown in ***Engineering Annex Appendix G4-IA.B, Section B2.A2*** for reference

b. CAD Subprojects

81. **RCC and PVC Pipes: Comparative Cost Effectiveness:** Buried pipelines for irrigation in command area development (CAD) subprojects were, previously, made using RCC pipes, sizes of which range from 300mm to 900 mm internal diameters. Since 2011, unplasticized PVC (uPVC) pipes are being used for nominal diameter requirements of up to 600 mm, as these pipe sizes are being produced locally, and for higher pipe diameters up to 900 mm, use of RCC pipes is continued as uPVC pipes of these higher diameters are not yet available with adequate technical requirements and cost effectiveness.

82. Though cost of uPVC pipes are higher than RCC pipes, the reasons for preferring uPVC pipes are (i) lengthy on-site manufacture of a huge number of RCC pipes with much difficulty in quality control is avoided; (ii) uPVC pipes are light and handling, placement, jointing are both easier and quicker; and (iii) number of joints i.e leaking possibilities reduce significantly as lengths of pipe units are longer and joints of uPVC pipes are much more leak resistant.

83. Capital cost of CAD subprojects under SSWRD projects using buried uPVC pipes are assessed to be typically BDT 60,000 to 100,000 per hectare irrigated area with 60-65 % of

the cost due to the pipes only. However, the apparent high cost should not be construed as "not cost effective" because cost effectiveness relates also to a few other things like (i) subproject being able to provide full irrigation to the whole area, not requiring to leave some part for the system out of service due to frequent/major leaks in pipe system, (ii) not only capital (construction) cost but the total cost including costs of pumping water, system operation (distribution management) and maintenance (leak repair, etc) of the system, etc.

84. The last completed project, SSWRD (JICA) -1, implemented 07 CAD subprojects with uPVC buried pipes, for the first time in larger areas, and 01 CAD subproject with RCC pipes. Previous SSWRD projects implemented several CAD subprojects with only RCC buried pipes. The uPVC buried pipe CAD subprojects are performing for 02 years now and have not indicated a single problem in the buried pipe system whereas the subproject with RCC pipe has already left a part of the area out of service temporarily due to the problem of leaking joints. For the previous CAD subprojects with RCC pipes, serious problems have been reported in all of them – some of them having gone out of service. Though it is too early to form an opinion, observations of this short period gives positive indication of cost effectiveness of uPVC buried pipe CAD subprojects.

85. **System Layout and Index Map of Subproject:** Layout planning of a CAD subproject is best done by using Google earth imagery of the subproject area, may be on a printed hard copy or working on-line using a GIS program. Google earth imagery gives ground elevation to an accuracy of 1.00 m which would be adequate for planning purpose. Subproject boundary should first be delineated by physical boundary, irrigable land, etc and considering that carrying water to more than about 2.50 km is not desirable from economic point of view. Natural drainage paths within the area are identified and then ridge ground alignments are identified to locate the irrigation pipelines.

86. The net command area, excluding the non-irrigable areas like homesteads, beels, etc is divided into more or less equal size "rotation units" of 80-130 ha areas. Rotation units in a subproject may be about 06 at the maximum from the view point of system management. Each rotation unit will be supplied by a separate pipeline. Branches spurring from these lines will have riser outlets. Each outlet will have 10-15 ha of land called an "irrigator unit". The whole command area will be provided with, as far as possible, equitable riser outlets. One rule of thumb is that risers should be spaced 200-500 m along the pipeline and no land should be more than 200-400 m from an outlet. Locations of header tank, other flow control structures and all outlet points are to be clearly shown in the layout plan. With this exercise of layout of pipelines and dividing the command area into rotation units and irrigator units, a draft statement of rotation and irrigator units and associated information will be prepared.

87. At this stage, stakeholders' agreement will be sought and having an approved basic layout of the irrigation system, the subproject Index map will be prepared and engineering surveys for sites of header tank and flow control structures and alignment of pipelines will be undertaken. The **Index Map,** with updates that may be needed as detail design of the system is progressed and completed, will be included in feasibility report in ***G4-IB Engineering Annex (CAD), Appendix G4-IB.C1*** (see example map in the attached Appendix)***.*** Also, based on the stakeholders agreed layout of pipelines, a schematic layout of skeletal pipelines with relevant data of all the pipe reaches between nodes are prepared. Diameter of pipes at this stage as shown in this schematic drawing is calculated from the area of land to be served by the pipe at the point, the average (3-month) duty of irrigation water and a desired moderate velocity in the pipe at 0.70 – 0.80 m/s. The schematic layout of pipe system with hydraulic data will be given in ***G4-IB Engineering Annex (CAD), Appendix G4-IB.C2*** of the feasibility report (see example map in the attached Appendix)***.***

88. **Crop Water Requirement, Irrigation Duty and Pipe Size:** Calculation of crop water requirement is quite complex. Details on the parameters, assumptions and limitations, different cropping scenarios, etc and the FAO approach of calculation are given in Guidelines Document **G6: Detail Design of Subproject Structures**, ***Exhibit G6-L: Criteria and Design of PVC Buried Pipe Irrigation Subprojects.***

89. The Exhibit provides crop water requirements and irrigation requirements of 13 districts of the country for different cropping scenarios. For SSWRD irrigation (CAD) subprojects, data of these 13 districts are considered adequate. Subprojects in any district will adopt data of one of these 13 districts (mostly the adjacent districts will govern) that is considered most appropriate for the hydro-climatic and agricultural condition of the subproject. Crop water and irrigation water requirements of the applicable reference district will be provided in the feasibility report in ***Engineering Annex (CAD), AppendixG4-IB.A, Table A3.***

90. An “irrigation Duty” (irrigation requirement at field level expressed in mm/day or l/s/ha) is to be adopted for a subproject depending on cropping pattern (percent land under a crop) of the subproject area and water requirement of the crop at the place that is dependent on factors like the crop and its growing stage (crop coefficient), type of soil (percolation and moisture holding capacity), crop coverage of land, evaporation and transpiration, etc. Two Duties will be used – *usual* Duty or *three-month* Duty (uniform Duty for three months of the crop period) for sizing the pipes and *peak* Duty or *one-month* Duty (Duty for the one month period of high water demand) to design height of the header tank and stand pipe. For the peak one month, pipes will flow with a higher velocity to convey more discharge as per the higher Duty.

91. The pipe lines are then divided into reaches separated by nodal points on the basis that pipe sizes should reduce as the command area of the pipe reach reduces. With the command area of a pipe reach so determined and knowing the irrigation duty, discharge required at the reach is calculated. Thus, a tabulation of command area-discharge-pipe diameter of all the reaches of pipes in all the pipe lines is drawn up. In calculating preliminary pipe size, a moderate flow velocity in the pipes as 0.7 to 0.8 m/s will be maintained for all the reaches and all pipe sizes. The system layout and calculations will lead to a tabulation of data on rotation units and irrigator units in the subproject including related other data like rotation discharges, flow control structures required etc. These, a summary data and information of the subproject, are provided in ***G4-IB Engineering Annex (CAD), Appendix G4-IB.B, Tables B3*** and ***B4***. Feasibility study Consultants will provide calculations of concerned subprojects and include the Appendices in the feasibility report appropriately. A skeletal layout of pipe system with the above calculated parameters will be given in a schematic diagram in ***G4-IB Engineering Anex (CAD), Appendix G4-IB.C2.***

3.2.6 Anticipated Impacts of Different Types of Subprojects

a. Drainage Improvement Subprojects

92. Drainage improvement works are designed to remove excess water from an area, and/or to reduce time required to drain that water. This is usually achieved by re-excavating existing drainage khals whose capacities have been reduced for being silted up or being encroached upon. Sometimes, excavation of new khal may also be required. Drainage improvement subprojects have impacts on agriculture and fisheries.

i. Impact on Agriculture

93. Possible agricultural benefits that can be derived from improved drainage are:

- Increased production of pulses and oilseeds in the Rabi season since crops can be planted earlier.
- Increased area under short duration crops (mustard, pulses, potatoes) between hyv Aman and hyv Boro.
- Reduced crop damage in Kharif I (pre-monsoon) and in Kharif II (monsoon) seasons.
- Additional land available for cropping where shallow swamplands (beels) are drained.

ii. Impact on Fisheries

94. Impacts of drainage improvement works on fisheries are as below:

- Reduced production of open water fisheries, both capture and cultivated, in the subproject area due to reduction of habitat,
- Re-excavation of drainage khals increase their depths of the khals and may increase water storage and thereby may improve fisheries habitat. However, impact of this on production is likely to be insignificant.

b. Tidal Irrigation Subprojects

95. Tidal Irrigation subprojects are limited for the areas where tidal water is fresh and suitable for irrigation. These subprojects are designed to re-excavate silted up tidal khals to increase availability of tidal water in the khals for irrigation use. Re-excavation increases flux of tidal water in the khals and also extends propagation of water more inland so that more area comes under irrigation. Tidal khals may be independent with branches that spread water up to certain points along their lengths or may form interconnected network when the whole khal system area gets water. The re-excavation may also benefit drainage. These subprojects have impact on both agriculture and fisheries.

i. Impact on Agriculture

96. Tidal irrigation subprojects, by way of increasing availability of water for irrigation, increases cultivation of Rabi crops – pulses, oil seeds, water melons and irrigated hyv Boro rice crops in extended areas.

ii. Impact on Fisheries

97. Re-excavation of tidal khals enhance fisheries habitat and increases open water capture fisheries.

c. Flood Management Subprojects

i Full and Partial Flood Management (FM) Subprojects for Areas of Different Water Regimes

98. Flood is usually related with monsoon season but in some areas, in the context of crops grown, flood during pre-monsoon season is critically important. Also flood regime, either monsoon or pre-monsoon, is different in different areas. Accordingly, two kinds of Flood Management subprojects are used based water regime and/or season.

99. **Full Flood Management Subproject:** Full FM subprojects use high embankments designed to protect Aus and Aman rice crops of the subproject area from monsoon floods. These subprojects are suitable for relatively shallow flooded areas and areas along flashy rivers. Also, in tidal areas where protection from saline water is required, full flood management subprojects are to be used.

100. Full Flood Management subprojects are generally not possible in deeply flooded areas because there is no drainage from the subproject area during the whole monsoon season (June-October) and accumulation of all rainfall during these months builds water such that cultivation is not possible. Under these conditions pump drainage is required for effective full flood management. Pump drainage is expensive, complex and not appropriate under SSWR development.

101. **Partial Flood Management Subprojects:** In deeply flooded areas like the Haors of greater Sylhet and Mymensingh and lower flood plains of big rivers, protecting HYV Boro rice crop from pre-monsoon floods is only important. In these areas and for this purpose, submersible embankments are used that protect subproject areas from pre-monsoon floods only and, as harvesting is done safely, get submerged as monsoon water builds high. These are called Partial FM subprojects.

ii. Impact on Agriculture

102. The Full Flood Management subprojects have two-fold positive impact on agricultural production: (a) Damage to crops due to flood is reduced, and (b) Land types changes as a result of reduced flood depth. Reduction in flood depth is assessed by the difference between the present (pre-subproject) and future (post-subproject) water levels.

103. The Partial Flood Management subprojects impact agricultural production by (a) saving 'nearly mature' to 'ready to harvest' crops from damage by submergence due to flash flood in outside rivers, and (b) reducing inside water depth. However, these subprojects cannot cause any land type change because there is no change in monsoon water level due to the subproject.

104. Present crop damage due to flood is estimated based on the crops grown in the area of the subproject that lies below the (a) 1:10-year pre-monsoon flood level for partial FM subprojects, and (b) 1:10-year monsoon flood level for full FM subprojects. These areas are calculated by using the water levels and the area-elevation–storage relationship data of the subproject document.

105. Estimation of land type change in full FM subproject is done by computing the (a) present (pre-subproject) land types of the subproject area considering 1:10-year HFL and (b) post-subproject land types by considering the design Monsoon Basin WL of the subproject, and taking the difference between post-project and pre-project values of respective land types. An example of involved calculations using the Spreadsheet Design Program is shown in ***Annex G4-IA: Engineering Annex, Appendix G4-IA.B, Section B2.A2*** (see also paragraphs on *Area-Elevation-Storage* and *Land Types Changes* above).

106. The pre-project and post-project WLs at the subproject that are criteria for agricultural analysis by seasons – pre-monsoon and post-monsoon and by subproject type – partial or full flood management are shown in ***Table III-1*** below.

Table III-1: Pre-Subproject and Post-Subproject WLs for Agricultural Analysis

Item	Pre-Project WL	Post-Project WL		
	Description	Description	Approximate Estimate	Detail Analysis
Pre-Monsoon Flood Protection with Submersible Embankments in Haor Areas (Land Type will not change)				
Pre-Monsoon Design	1:10-year May HFL in outfall river (at SPsite)	Design Basin WL generated by pre-monsn	May [(Mean Max WL +	Basin Water Level determined from routing of the Pre-Monsoon Design

Item	Pre-Project WL	Post-Project WL		
	Description	Description	Approximate Estimate	Detail Analysis
Flood Level		Design Storm (5-day, 1:10-yr storm rainfall)	Mean Min WL)/2+0.3]	Storm using a Drainage Rate that correspond to project acceptable crop damage criteria.
Pre-Monsoon Flood Protection with Submersible Embankments in Other Areas (Land Type will not change)				
Pre-Monsoon Design Flood Level	1:10-year Jun HFL in outfall river (at SPsite)	Design Basin WL generated by pre-monsn Design Storm (5-day, 1:10-yr storm rainfall)	<u>Freshwater Tidal Areas</u> Jun [(Mean Max WL + Mean Min WL)/2+0.3] <u>Non-Tidal Areas:</u> June Mean WL + 0.3m	Basin Water Level determined from routing of the Pre-Monsoon Design Storm using a Drainage Rate that correspond to project accepted crop damage criteria.
Monsoon Flood Protection with High Embankments (Land Type will change according to Post-Project Basin Water Level)				
Monsoon Season Design Flood Level	1:10-yr Annual HFL in outfall river (at SPsite)	Design Basin WL_generated by monsoon Design Storm (5-day, 1:10-yr storm rainfall)	<u>Tidal Areas</u>: Jul-Aug[(Mean Max WL + Mean Min WL)/2+0.3] <u>Non-Tidal Areas</u>: July- August Mean WL+ 0.3 m	1. <u>Outfall river WL permits drainage</u>: Basin Water Level determined from routing of Monsoon Design Storm using a Drainage Rate that correspond to project accepted crop damage criteria. 2.O<u>utfall WL does not permit drainage</u>: Basin Water Level determined from monthly Water Balance analysis. (ref: Para 88).

Notes: 1. The “Approximate Estimate” of post-project Basin WL may be used at prefeasibility analysis.
2. Basin WL determined by "Detail Analysis" should be used in feasibility analysis.

107. The design Monsoon Basin WL of a subproject is most appropriately estimated by a flood routing analysis for the monsoon months, June to October. This requires 1 in 10 year daily rainfall inside the protected area and 1 in 10 year daily water levels of the outfall river for the whole period – June to October. The flood routing analysis is then done as a water balance calculation exercise with the simple relationship – *‘day inflow less evapo-transpiration’* minus *‘day outflow’ equals ‘change in basin storage’*. In practice, however, water levels of a particular year of which the max WL is equal or closely equal to the computed 1 in 10 year HFL value are taken. Similarly, daily rainfall data of the particular year of which the total rainfall equals or nearly equals to the computed 1 in 10 year annual rainfall are taken. The computation can be done using a Excel Spreadsheet Program.

108. To reduce computational works, an approximate flood routing analysis may be done by using 10-day steps of analysis instead of the daily and using average 10-daily WL and rainfall values.

109. When outside water level is high allowing no drainage, monsoon basin water level for full FM subprojects may be determined by accumulating total rainfalls of June to October months less by evapo-transpiration during this period and converting this depth of runoff from the whole subproject area into volume [(total rainfall less total evapo-transpiration in

mm) x (drainage area of subproject in hectares)] of water in storage in the basin that gives the basin water level when applied on the area-elevation-storage data of the subproject..

110. Though full FM subprojects usually cause change in land type, it may be at times that land type change is not significant. It is usually considered that if difference between pre-subproject and post subproject water levels is 0.3 m or less, the subproject is considered to produce no land type change. However, the high embankment subprojects under such condition will also benefit the subproject area by protecting crops from higher than average monsoon floods (1in 5 year, 1in 8 year, etc) under proper flood management by closing and opening gates with rising and falling outside water levels (this is one mode of fish friendly gate operation in FM subprojects).

111. Estimate of crop damage due to floods made from areas inundated under the criteria WLs may be in error due to incorrect estimation of flood levels and/or subproject ground topography. To avoid such error, the calculated crop damage due to flood should be cross checked by using primary agriculture data collected from field (refer ***3.3 Agricultural Analysis*** in this document).

iii. Impact on Fisheries

112. While reduced flood level resulting from Flood Management subprojects has positive impact on agriculture, it has negative impact on fisheries. However, the bases for estimating the impacts are different. While the flood protection *agricultural benefit* estimates include protected land defined by 1:10-year flood level, which is derived from extreme-short duration peaks that damage crops, the *fisheries damage* refers to flood plain area that is used by migrating fishes as grazing ground for longer time during flood season.

113. For seasonally flooded land to be considered as fish grazing ground it has to remain inundated for a reasonable period of time. To eliminate any short duration inundated land, the floodplain fisheries have been defined as land that is inundated by annual average flood to more than 0.90 m depth, which corresponds to agricultural land types F2 and F3. The criteria for estimating changes in flood plain areas due to subproject intervention are given in ***Table III-2*** below.

Table III-2: Pre-Subproject and Post-Subproject WLs for Fisheries Analysis

Item	**Pre-Subproject Habitat**	**Post-Subproject Habitat**		
	Description	**Description**	**Approx Estimate**	**Detail Analysis**
Partial Flood Management Subprojects with Submersible Embankments (monsoon flood plain area will not change)				
Present Floodplain Fish Habitat	Depth of flooding from average monsoon HFL (1:2.33-yr Annual HFL) more than 0.90 m. [present area of F2 +F3 lands]	Depth of flooding from average monsoon HFL (1:2.33-yr Annual HFL) more than 0.90 m. [present area of F2 +F3 lands]	No change	Determine impact of disruption of fish migration in April - June on annual fish production from field data.
Full Flood Management Subprojects with High Embankments (Flood plain fish grazing area will change according to effective basin water level)				

Present Floodplain Fish Habitat	Depth of flooding from average monsoon HFL (1:2.33-yr Annual HFL) more than 0.90 m. [present area of F2 +F3 lands]	Depth of flooding from Design Basin WL more than 0.90 m. [post-subproject area of F2 +F3 lands]	Change	Calculated from Area-Elevation-Storage relation corresponding to WL= Design Basin WL – 0..9m [Post subproject area of F2 + F3 lands]

d. Water Conservation Subprojects (including Rubber Dam Subprojects)

i Impact on Agriculture

114. It is assumed that all water retained by a hydraulic structure is available for irrigation of HYV Boro rice crop within the area of influence of the water body – khal or Beel. The benefited area is evaluated by determining the amount of land that can be irrigated by the available water considering the required depth of irrigation water application at the subproject.

115. Irrigation may be done by gravity and/or lifting water by LLPs or other means. Assuming that water from the khal including branch khals, if any, or Beel can be taken up to about 250m by earthen field channels and to some more distance, say 350m, by using lay-flat hose pipes, the width of command area would be 500 – 700 m considering both sides of the khal or Beel. This strip of command area is assumed to extend along the length of the khal and branch khals up to the point where bed level of the khal equals the maximum water retention level. This area may be defined as the gross command area whereas the net command/benefited area will be determined from water availability consideration.

116. For Rubber Dam subprojects, storage water volume is usually larger and organized irrigation schemes are set along the river by pump owners who lift and distribute water to farmers' plots under their own management and collect project specified service fees from farmers on irrigated land area basis. Here, irrigation water can be taken further inside compared to individual farmers efforts. Accordingly, benefitted area may simply be calculated based on available quantity of water, including return flow from irrigation fields, and crop water requirement.

117. Beside what water was initially stored and available from the dry season flow of the khal/chhara, return flow from irrigation fields (irrigated either by water from this storage or by groundwater) in the catchment area contributes to the storage. An estimate of possible irrigation return flow may be made using a thumb assumption of 15-20 percent of applied water.

118. In some areas, Aman rice crop suffers from long rainless periods, up to about three weeks, causing drought stress on the crop at its flowering stage. Water Conservation subprojects can support supplementary irrigation to Aman crop in such conditions.

119. In addition to providing water for dry season irrigation, water conservation subprojects increase residual moisture available within the soil profile. This can facilitate cultivation of early rabi crops, though for the purpose of the impact analysis, this benefit is difficult to quantify and thus not factored into the overall benefit analysis.

ii. Impact on Fisheries

120. Usually, gated water retention structures and Rubber Dams with low inverts at bed levels of khals/rivers are built in water conservation subprojects. Fixed weirs of elevated sills are also constructed in some subprojects, though rarely because of their inherent characteristic of obstructing monsoon drainage and causing higher flood level in the upstream. The weirs overflow for drainage and remain submerged under monsoon water.

121. The gated water retention structures and Rubber Dams remain fully open during pre-monsoon and monsoon and as such have practically no impact on monsoon habitat and migration/movement of fisheries. These subprojects, on the other hand, improve post-monsoon to dry season habitat of fisheries in khals/rivers and beels for a few months through storage of water for irrigation. Impact on fisheries production due to this has not been significant. However, there is significant potential of fisheries production in Rubber Dam reservoirs, compared to other water retention structures, as the reservoirs are usually bigger.

122. The elevated sill weirs obstruct pre-monsoon to early monsoon migration/movement of fishes and thus have some adverse impact. However, the migration/movement opens up in monsoon as the dams get submerged and, in post-monsoon to dry season, habitats in the khals and beels improve.

e. Command Area Development (CAD) Subprojects

i. Impact on Agriculture

123. The command area development subprojects include rehabilitation of existing and construction of new / additional infrastructure for water distribution within irrigation systems. The direct impact of CAD subprojects is reflected by additional cultivable area brought under irrigated agriculture and/or improved water availability for timely irrigation that improves yield.

124. The indirect impacts of CAD subprojects are increased efficiency in use of irrigation water and improved water management, which result in reduced cost of crop production.

ii. Impact on Fisheries

125. CAD subprojects usually have no impact, either positive or negative, on fisheries. However, in dry areas, some people are seen to excavate ponds for fish culture based on drawing water to their ponds from the irrigation system. The impact is not seen as significant.

3.2.7 Determination of Subproject Benefited Areas for Different Subprojects

a. Drainage Improvement Subprojects

126. To determine the benefited area of a drainage improvement subproject it is necessary to establish (i) pre-subproject area affected by inadequate drainage and (ii) post-subproject area that remains affected by inadequate drainage (if any). The pre-subproject boundary of affected area should be demarcated on the subproject Index Map and measured. Water level corresponding to this pre-subproject affected area can be established from land elevation contour values along the periphery line of this area. The post subproject level below which lands cannot be drained would be given by design bed level of the drainage khal or sill level of regulator, if any, used to retain water in the khal or low water level of outfall river or khal that limits drainage. The boundary corresponding to this level can be drawn on the subproject Index Map with contour lines and measured. The difference between these two measurements gives the subproject's benefited area. In case of drainage of lowlands, the area reclaimed from the uncultivable lowland may increase the benefited

area. In case of new drainage khal excavation, the benefited area should include loss of cultivable land taken by the channel.

127. With the pre-subproject and post-subproject drainage affected water levels known, the area-elevation-storage relationship of the subproject can be used to calculate land types under both the water levels and the differences between land type figures give the benefitted areas by land types.

b. Tidal Irrigation Subprojects

128. Khals re-excavated for enhancement of tidal water availability for irrigation use may be independent single khal or with tributary branches. In such conditions, length of khal coming fresh under water supply determines the benefitted area with a strip width of 500-700 meters along the length of the khals. This length can be known from field information to what point water was reaching under pre-project time and from design condition to what point water will reach after re-excavation a per design. Tide cycle is approximately of 12 hours of which for six hours water in the khal will be in rising and for the next six hours water level remains in falling. It is complex to calculate how much water is available from a khal supplied by tides as it is related with re-excavated bed level of khal and LTL that is variable with time – days over the months and years. It can however be assumed in general that if the re-excavation provide about 500 mm depth of water below the LTL at the beginning of the khal, it may supply adequate water for irrigation of command area under it. The benefited area estimated as above will hold even some pumps go idle during low tides. Where the re-excavated khals form close network, the whole subproject area may be considered as the post project benefit area while the pre-project area would be noted from field information.

129. The benefited areas as outlined above if demarcated on the subproject Index Map and the range of land elevations in which the benefited area belongs is known from contour values, the land type distribution of the benefited area can be known.

c. Flood Management Subprojects

130. The 1:10-year pre-subproject annual flood level defines the upper limit of benefited area of full flood protection subprojects, while the design Basin Water Level defines the lower limit of benefited area. Difference between the two areas within the subproject boundary gives the subproject gross benefited area. This area may include cultivable land, homesteads, roads and other lands that are negatively affected by flood.

131. The subproject net benefited area refers to cultivable land and it should include only the cultivable land within the demarcated gross benefited area of a subproject.

132. The Subproject Index Map with land elevation contours and topographical futures of the area should be used for demarcation and measurement of benefited areas.

133. The above two water levels – the 1:10-year HFL and the design Basin WL if worked with the area-elevation relationship of the subproject area will provide land types under each WL and the difference will give the benefitted area by land types.

d. Water Conservation Subprojects

134. Water conservation subprojects develop water storage capacity in baors, beels and/or existing khals /rivers to increase availability of irrigation water by installing water retention or regulator structures or Rubber Dams to regulate outflow from and conserve water inside the subproject.

135. Water conservation subprojects are designed for irrigation by gravity or using LLPs. The extent of benefited area on either sides of the storage channel depends on the distance

water can be conveyed by the system adopted by farmers - gravity channels, LLPs, etc. Assuming that water from the khal or Beel can be taken up to about 300-400 m by earthen field channels (actual distance may differ), the width of command area will be 600- 800 m both sides of the khal or Beel. The meeting point of the design water retention level with the design bed elevation of the khal defines the longitudinal limit (distance) of the benefited area. Command areas of water conservation subprojects are defined by these widths and lengths.

136. However, net irrigated area under the subproject will depend on available quantity of water in the storage (including perennial flow from upstream) and irrigation water requirement (including supplementation from other sources like groundwater) in the command area lands.

137. The benefited areas as outlined above if demarcated on the subproject Index Map and the range of land elevations in which the benefited area belongs is known from contour values, the land type distribution of the benefited area can be known.

e. Command Area Development Subprojects

138. If a CAD subproject involves rehabilitation of a whole existing irrigation system the benefited area will include the whole subproject irrigated area. Most of the SSWR CAD subprojects are of this type. In case the subproject is only for expanding existing command area by constructing additional irrigation canals, etc the benefited area will be the only new or additional irrigated area.

139. Other cases may include rehabilitation of different components of the irrigation system like pumping station, main canals, secondary canals or cross drainage and other infrastructure. In such case the benefited area that will be considered for the work will depend on how much of the net subproject irrigated area is affected by the proposed works.

140. Net irrigated area of a CAD subproject (whole irrigation system) will depend on quantity of water available from the pump and irrigation water requirement of crops grown in the command area.

3.3 Agricultural Analysis

3.3.1 Introduction

141. The purpose of agricultural analysis in feasibility study of subprojects is to estimate the impacts of subproject on agriculture, that is, the difference between “present” and “future with-subproject” agriculture inside the subproject area. The impact, expressed in terms of increase in agricultural production that is finally converted into economic return from the subproject, is required to justify investment in the subproject. Cropping pattern in the present and future with-subproject conditions are assumed to be identical.

3.3.2 Data Requirement and Collection

142. The Agriculturist of FS Consultant Firm assisted by field surveyors, as required, will collect primary agricultural data for each subproject. Any project staff in agriculture at district level, if available, will monitor the field activities.

143. Data will be collected by using the standardized Field Survey Forms for Agricultural Data and Information given in ***Exhibit G4-E, Tables G4-E.1 through G4-E.6*** appended to this document. Project Consultants - PMO will organize short orientation course to explain the data collection forms and the procedure to follow in conducting the survey. Supplementary information, particularly, on future plans for the area should be collected from the office of Upazila Agricultural Extension Officer.

144. Primary data should be collected in three ways and cross checked in the field between sources as much as possible. Collection methods to be used are:

- farmer interviews,
- direct visual observation of subproject agriculture, and
- discussions with Sub-Assistant Agriculture Officers working in the subproject area at Union levels. .

145. Farmer interviews, following the standard Field Survey Forms will be taken in group discussions at different sites within the subproject area. The interviews will determine:

- present land utilization
- present crop patterns on various land types
- percent of area under each crop pattern
- extent of crop damage due to flooding in different seasons, drought, and pest
- date and area of crop damage
- yield levels under normal and damaged conditions
- percent of crop area under different methods of irrigation
- crop planting and harvesting dates
- application rates of fertilizers and manure
- labor and draught power use
- constraints to agricultural production
- suggestions as to the nature of the interventions required to resolve the constraints
- views on possible impacts of the proposed subproject infrastructure.

146. Three main secondary sources shall be used to augment and cross-check the collected field data:

Upazila Land and Soil Use Guide, Soil Resources Development Institute / Ministry of Agriculture 1991. Guides exist for all the project area Upazilas. Each guide includes an upazila map at a scale of 1:50,000 and provides information on soil associations, soil series, cultivated land type, present land use, limitation to crop production, opportunities for development, crop yield level, and type and status of soil.

District Reconnaissance Soil Survey, Department of Soil Survey (now SRDI), 1970s. This is a series of district guides. Each guide includes a map at scale of 1:125,000 and provides the same information as the upazila guide, though at a coarser resolution.

Agro-Ecological Regions of Bangladesh*, Report 2*, Land Resource Appraisal of Bangladesh, 1988 (UNDP report DBD/8/035). Includes a map at a scale of 1:750,000 and provides information on physiography, agroecological zones and sub-zones, drainage and physical properties of the soils.

147. In addition, Index Map of subprojects in Google image and in 4 inch to 1 mile topographic maps with contours will be used.

148. Findings of earlier studies / reports – Reconnaissance and PRA will be duly used in this analysis.

3.3.3 Agricultural Impact Analysis

149. The objectives and methods used for determining agricultural impacts of flood management, drainage and irrigation subprojects are:

- Establish crop patterns and production on each land type found within the subproject area.
- Determine the area on which flood damage occurs under present subproject conditions.
- Determine the changes in area under each land type based on new flood levels or on the provision of drainage improvement or irrigation corresponding to type of subprojects (refer: Sub-section 3.2.6, Para on benefitted land types).
- Predict changes in production levels by assuming that those cropping patterns presently found on a given land type would be found over the new area of that land type under post-project conditions. Yields are assumed to remain unchanged unless there is flood damage prior to the provision of the infrastructure. In this event, undamaged pre-project yields should be used in the post-project condition.
- In cases where supplementary irrigation is provided for the kharif II crops (mainly transplanted Aman), under pre-subproject (droughty) conditions, reduced yields should be used. With the provision of supplementary irrigation, normal yields are predicted.
- Where supplementary irrigation is provided concurrently with flood management and/or improved drainage, the post-project crop patterns on a given land type are a combination of pre-project crop patterns on the two or more land types from which the post-subproject land type is derived.
- In cases where winter season (Boro) irrigation is made available, irrigated crops, usually Boro hyv rice or Wheat should be incorporated into the crop pattern in accordance with the volume of irrigation water made available.

150. Crop budgets prepared for standard crops cultivated in SSWR subproject areas under conditions of "without" and "with" water management are given in the appended ***Exhibit G4-G: Economic Analysis, Table G4-G.7*** as reference. The crop budgets are based on (i) yield data and input use rates including labour and draught power standardized for each crop based on field survey data after verification with data from secondary sources such as Bangladesh Bureau of Statistics, (ii) farm gate prices of internationally traded commodities calculated using World Bank price forecast of July, 2016 and (iii) prices (2017) of local agricultural input and output products given by Department of Agricultural Marketing. However, as these are market sensitive data, each project will prepare a fresh crop budget for use in feasibility analysis of its subprojects. Further, it may be necessary to update project crop budget if component prices change significantly during project period.

3.4 Fisheries Analysis

3.4.1 Introduction

151. Purpose of fisheries analysis in feasibility study of subprojects is to estimate the impact of proposed subproject on fisheries; specifically, the difference between "present" and "future-with subproject" conditions. Because of limitations of generally available data, the state of fisheries in the "future-without subproject" is assumed to be the same as the "present". This approach, in many areas should lead to fairly conservative estimates of fisheries impacts since in much of the region fish production has been declining, probably

due to habitat loss from infrastructure development (including water resources) and over-fishing.

3.4.2 Data Requirement and Collection

152. Fisheries Specialist of the FS Consultant Firm will collect primary fisheries data. Any project staff on fisheries specialization, if available at the field level, will coordinate and monitor the data collection activities. Data should be collected using the standardized forms for Fisheries Field Survey and Data Collection given in the appended **Exhibit G4-F**. Sources for primary data and information on fisheries in the subproject area and surroundings include:

- Group discussions with village leaders, representatives of Union Parishad, fishermen, and farmers.
- Direct visual observations of subproject fishery resources.
- Discussions with Department of Fisheries (DOF) officials working in the subproject area.

153. Secondary data are required to validate the primary data collected from the field and these should be obtained from the following sources:

- Fisheries Information Bulletin, Volume 3, No 1 Water Area Statistics of Bangladesh, Fisheries Resource Survey System, Department of Fisheries
- Fish Catch Statistics of Bangladesh, Department of Fisheries
- Fisheries Studies and Pilot Project, FAP 17, Final Report

154. To assess impact of a SSWRD subproject in the fisheries sector, the required data and information should include:

- List of open water fisheries inside and around subproject area;
- Area, condition and location of fisheries habitat inside the subproject
- Present area of culture fisheries and permanent open water fisheries inside the subproject area
- Estimated fish production in the identified fisheries
- Demarcation of present floodplain fisheries boundaries and fish migration routes/points shown on subproject planning maps (4" to 1 mile topo map and Google image)
- Dates of fish migration through the identified routes
- Fish marketing centers in the area
- Reaction of fishing community to the proposed works.

3.4.3 Analysis of Fisheries Impact

155. The fisheries impact analysis will comprise:

a. An assessment of subproject negative fisheries impacts, considering the "worst case" scenario, in terms of:

   - Habitat extent (floodplain area, seasonal and permanent water body areas in hectares) and duration (number of months flooded) estimated on the basis of pre- and post-subproject land types
   - Habitat quality (blockage of fish movement by embankments, closures, and water management structures, interruption (intermittent or permanent) of fish movement by proposed infrastructure)

- Fish production, employment in fishing, and subsistence fisher nutrition

b. An assessment of potential positive impacts inherent in the basic subproject design such as improvements in habitat quality related to re-excavation of drainage khals; increased (compensatory) employment of landless laborers in agriculture

c. An assessment of the feasibility and potential impacts of any relevant add-on mitigating and compensating measures such as modifying structure designs and operating practices to minimize open water fisheries damage and measures to promote aquaculture.

d. An assessment of net fisheries impacts (subproject negative impacts + subproject positive impacts + add-on mitigation/compensation impacts).

156. The subproject impact on fisheries is a combination of impact due to changes in habitat area and changes due to reduction in catch per ha of habitat. Both of these are incorporated in the model for economic analysis of the subprojects.

157. Nominal quantification of pre- and post-subproject habitat extent (for various habitat types) is possible based on hydrological analysis of land type changes for FM subprojects. Drainage, tidal irrigation and water conservation subprojects will not have any land type change. Tidal irrigation and water conservation subprojects add some dry season habitat in khals.

158. Where better data is unavailable, fish catch on floodplains (land presently flooded throughout monsoon season, which corresponds to the area of F2 + F3 lands) can be assumed to be 50 kg/ha, and in permanent water bodies 220 kg/ha. In general, without mitigation measures, it can be assumed that flood management infrastructures reduce these values by 50%.

159. In case of drainage improvement by excavating and/or re-excavating drainage channels without any structure across the channel, post-subproject fish catch should be assumed to be equal to pre-subproject catch.

160. Fisheries budgets should be prepared separately for floodplain and perennial water bodies on the basis of per hectare habitat and the quantities and costs/prices used should be based on data from Department of Fisheries.

161. For floodplain fisheries, it can be assumed that:

- The pre-subproject level of effort is 30 person-days per hectare and it is expected to drop to 20 person-days per hectare under the with subproject scenario, mainly due to reduced fish yield. Nevertheless, it can be recognized that numerous variables affect the level of effort such as effective fishing days per year and depth of water body;
- Average fishing wage is assumed to be Tk 70 per person-day, which is comparable to farm labor (used in the financial analysis);
- No hired labor is used; all fishers are subsistence type and therefore labor value can be considered at zero, for the financial analysis;
- Gear and craft cost estimated at 10 and 5 per cent of catch value under pre-subproject conditions. This cost will be reduced by 50 per cent under post-subproject conditions;
- There will be no lease fee for floodplain fisheries; and
- There will be no costs associated with guarding the fishery.

162. For perennial water bodies, it is assumed that:

- Level of effort is 50 person-days per hectare (40 pd/ha with subproject);
- Average fishing wage is assumed to be Tk 70 per person-day, which is comparable to farm labor (used in the financial analysis);
- The perennial water bodies are generally leased to wealthier members of the community who do not provide their own labor and therefore all labor would be hired;
- Gear and craft cost was estimated at 20 and 10 per cent of catch value under pre-and post-subproject conditions;
- Lease fees per hectare under pre-subproject conditions are averaged to Tk 1000 per hectare of water body. The current fees should be reduced by 50 per cent in the post-subproject conditions (in proportion to the reduction of the catch); and
- Fees to guard the fishery should be included.

3.5 Social Analysis

3.5.1 Introduction

163. The overall objective of social assessment of subprojects is to assess whether a proposed subproject is *socially sound and institutionally viable*. This can be determined by assessing how broad-based is local public support for the subproject and if people agree to get organized in an association for the management of local water resources. And these will be judged by applying the following socio-institutional criteria on the various data and condition existing in the subproject area:

- More than 40% of the subproject benefited area is operated by landless share croppers and marginal or small farmers owning less than 1.0 ha of land.
- Local people must support the proposed subproject on the grounds that the subproject will benefit them.
- The beneficiaries must be willing to form a Water Management Co-operative Association (WMCA).
- Conditions for a feasible WMCA exist (no major social conflicts; affected area, number of beneficiaries and affected people, villages and Unions limited to a manageable size; community is not dominated by influential few individuals with different interests).
  The key persons (potential beneficiaries attending group discussion/interview) must commit themselves to paying before implementation 1.5% of the cost of structure and 3% of the cost of earthworks (5% for submersible embankment) toward annual O&M expenses.

3.5.2 Data Requirement and Collection

164. Data used in the analysis will be primary data collected from field. However, the field data will be checked with secondary data of the Bangladesh Bureau of Statistics (BBS) which would be available readily with Union Parishads and Upazila Statistical Offices. Extensive social and socio-economic data will be collected by the PRA study. FS Consultant will use data and information on social, socio-economic and women aspects from PRA report which forms ***Annex II*** of the Feasibility Report of the subproject. However, the FS Consultant will review those data before use and may undertake sample checks of the data using secondary sources and also at the field, if necessary.

3.5.3 Definition of Poverty Level

165. A poverty line will be drawn for the beneficiaries of the subproject by using the *Household Income Criteria*. The household income currently used in defining poverty line is Tk. 634 per person per month. As this is dependent on inflation rate, etc, the figure needs to be appropriately redefined for individual projects. In terms of family size, the household incomes are as below:

- less than Tk 1,900/- per month for a family of 3
- less than Tk 2,536/- per month for a family of 4
- less than Tk 3,170/- per month for a family of 5, etc.
-

166. In case of difficulties in obtaining reliable information about household income, the following criteria may be used to define the poverty level:

- Households cultivating own or leased land less than 0.2 ha,
- Landless person working as farm laborer or non-farm worker, and
- Household engaged in small fishing or petty business or service.

3.5.4 Analysis for Social and Socio-Economic Assessment

167. The analysis involves compilation and verification of field data to ensure that subproject criteria are being met and to ensure that there are possible solutions to local disagreements, if any. Where the required socio-institutional viability criteria given in ***Section 3.5.1: Introduction*** above is not met, or resolving of local disagreement is not possible, the subproject should be recommended for deferral.

168. The selection criteria concerning benefited land operation by landless to small farmers should be applied in its stated form. That is, only those proposed subprojects in which more than 40 per cent of benefited area is operated by landless sharecroppers, and/or marginal or small farmers (owning up to 1.0 ha) will be considered for recommendation regarding social viability.

169. The sections on social and institutional viability included in feasibility study of subprojects will draw upon field data and information on social and socio-economic profile of the benefitted population and on viability of the Water Management Cooperative Association (WMCA), collected under PRA study vide ***Exhibit G3-A, Forms G3-A.5 (social)*** and ***G3-A.6 (women)*** and provide succinct but clear analytical comments on the following issues in relation with subprojects socio-institutional selection criteria.

- Farm size distribution, land ownership, and household occupation of the landless,
- Poverty level and its assessment,
- Wage rates of farm and non-farm day laborers –both male and female,.
- Migration of laborers – in-migration and out-migration, male and female laborers
- Assessment of the present levels of involvement and cooperation of local people in local organizational / institutional activities,
- Assessment of the level of support or opposition to the subproject by interest groups inside and outside subproject area,
- Assessment of possible negative impact outside of subproject boundary, and occupational profile of negatively impacted people,
- Assessment of overall viability of the institution - Water Management Cooperative Association,
- Assessment of willingness of people of subproject area to form a multi-purpose cooperative society (WMCA),

- Assessment of willingness to pay an upfront contribution to the O&M fund of the WMCA before starting the subproject construction, and.

170. Observations/findings on Indigenous People[1], if present within or outside of the subproject and their comment about the subproject must be described elaborately.

3.6 Environmental Assessment, Planning and Management

3.6.1 Introduction

171. Projects for SSWR development comprise of a large number of subprojects that are identified, studied and implemented in a rolling process throughout the period of the project implementation and thus the subprojects that will be implemented are not known beforehand. However, by criteria, the subprojects must be small – less than 1000 ha benefited area, only involve rehabilitation of existing systems for improving water management to enhance agricultural and fisheries production. Accordingly, SSWRD projects and, for that matter, all SSWRD subprojects are in Category B (Orange) of the *Bangladesh Environment Conservation Rules, 1997* that are not likely to have significant adverse environmental impacts. The SSWRD projects are therefore given environmental clearance for implementation subject to the condition that environmental assessment of all subprojects under the project shall be done and copies sent to the DOE for review and clearance. Detail Guidelines for Environmental Assessment of SSWRD Subprojects are given in Document ***G5: Environmental Assessment of Subprojects***. Environmental feasibility analysis of subprojects required for the FS study will draw upon the above Environmental Assessment Report of the subproject which will be appended to the FS Report as ***Annex-III***.

3.6.2 Data Requirement and Collection

172. Data required to carry out environmental assessment includes data and information from the subproject area and also from adjacent areas outside the subproject. These include information and data that will be used as benchmarks for future impact monitoring. A general list of data required for environmental assessment is listed below. Recent field data and individual subproject designs should be used to carry out the environmental assessment. For collection of detail specific data the feasibility study Consultant will use the standardized forms developed through the past SSWRD projects - Questionnaire for Environmental Field Data Collection as shown in Document ***G5 Environmental Assessment of Subprojects, Exhibit G5-B.***

a. Data from inside the subproject area

On Physical Environment:	Flood, drainage/waterlogging, water quality, soil characteristics, soil fertility.
On Biological Environment:	Aquatic and terrestrial habitat, fisheries, biodiversity.
On Social Environment:	Agricultural development, land acquisition/loss, accessibility, employment, health/nutrition, community impact, cultural values

b. Data from adjacent area

Information on general environment: dissimilarity/specialty in condition/ environment with the subproject area, if any.

[1] Working definition of indigenous peoples (by ADB): Indigenous peoples should be regarded as those with social or cultural identity distinct from the dominant or mainstream society, which makes them vulnerable to being disadvantaged in the processes of development.

On adverse impacts, risks:	Local people's comment on these that may arise in their area due to the subproject implementation with suggested remedial measures.
On any possible positive impact:	Local people's comment on this that may come for their area due to the subproject.

3.6.3 Environmental Planning

173. Environmental planning refers to measures taken proactively to identify and avoid or address, early in the subproject cycle, environmental concerns including potential adverse impacts. Environmental planning activities should,

- address impact assessment & monitoring requirements to improve the overall subproject planning system and planning of some selected disciplines.
- explore environmental sustainability issues, and
- review and improve reporting for completeness, accuracy, and responsiveness to stakeholders.

3.6.4 Assessment of Environmental Feasibility

174. Specifically designed methods to obtain relevant information, based on the foregoing analysis, shall be applied for Environmental Assessment (EA). The objective of EA is to determine, on the basis of existing information, whether:

c. **Based on Initial Environmental Examination (IEE), enough is known to conclude that the subprojects' impacts are within acceptable limits and environmentally feasible.**

d. **Enough is known to conclude that subproject impacts are unacceptable and the subproject design must be modified or dropped, or**

e. **The existing information is inadequate to determine if impacts are acceptable. Therefore, a detail Environmental Impact Assessment (EIA) involving further field studies is required. In this case, the EA would include a TOR for the EIA focused on the areas of uncertainty or concern.**

175. The SSWRDP subprojects falling in (a) above shall be cleared to proceed. As there is no provision to undertake EIA, subprojects falling in (b) shall be deferred for further review for a modified design or be dropped. For the subprojects under (c), EIA will be conducted and depending on the outcome of EIA results, prepared in consultation with the subproject planners, the subproject will be either dropped or cleared to proceed.

176. The IEE/EIA procedures include the following steps. The details of conducting IEE or EIA are given in ***G5 Environmental Assessment of Subprojects.***

- Site reconnaissance and scoping of important environmental components (IEC).
- Collection of field information for IEE/EIA and data for impact monitoring.
- Analysis of impacts and preparation of IEE/EIA report including outline of environmental management plan (EMP).

3.6.5 Environmental Management

177. Environmental management refers to activities related to environmental performance of the subproject during construction and operation. Environmental management therefore relates to the preparation and implementation of mitigation, compensation, monitoring and institutional measures and reporting on their implementation and results. Environmental management activities include:

- Monitoring and improvement of enhancement and mitigation methodology packages formulated by discipline specialists.
- Formulation of additional enhancement and mitigation methods, for resources/concerns not addressed by other disciplines.
- Monitoring of subproject planning and design stage activities related to mitigation and enhancement procedures and measures.
- Preparation of preliminary environmental management plan (EMP) for individual subprojects, as part of EA. Detail implementation arrangements for EMPs shall be developed in consultation with WMCAs during subproject construction and operation.
- Follow-up on the implementation of proposed environmental management measures.

178. Implementing projects will prepare EMP for each subproject during IEE. The EMP used in the just completed JICA supported SSWRD Project (2009-2015) is given in ***G5 Environmental Assessment of Subprojects, Exhibit G5-G.***

3.7 Development and Institutionalization of Beneficiaries Participation

3.7.1 Preamble

179. The purpose of this section is to present a synoptic picture of beneficiaries' participation development initiatives and efforts continued along with the process of preparing the subproject from its identification to construction completion and handing over to the WMCA. The elements of beneficiaries' participation are common for all subprojects – that is these are not different depending on type of subprojects. Broadly, the elements can be divided into:

- Initial mobilization of beneficiaries through consultative participation,
- Institutional mobilization of beneficiaries and formation of WMCA
- Beneficiary Commitment to Operation and Maintenance

180. Beneficiaries' participation is an essential key aspect in developing SSWR subprojects because the subprojects will be operated, maintained and managed by the beneficiaries after their construction are completed. Experience from the implemented SSWRD projects has shown, as it should have been, that where WMCAs cared for it, the subprojects performed well. That is to say, development of a good and capable WMCA is as important as implementing technically good infrastructure for a subproject. Therefore, the activities related to beneficiaries participation development and institutionalization need to be conducted very diligently and persuasively.

3.7.2 Initial Mobilization of Beneficiaries through Consultative Participation

181. When the Union Parishad receives a request for a subproject from local farmers, the Parishad discuss the request in a meeting and prepare a subproject proposal in the specified ***Form-1*** and approach LGED Upazila Engineer for assistance for its implementation. The

Upazila Engineer visits the area of the proposed subproject to assess the problems and proposed solutions. To do so, the Upazila Engineer discusses with local people of different classes, both inside and outside the area, to obtain their views about the proposed subproject. He specifically discusses people who might be negatively affected by the subproject.

182. When the LGED Upazila Engineer is reasonably satisfied that the subproject has both technical and social potential, he prepares technical documentation of the proposed subproject in specified ***Form-2*** and submits to the Upazila Parishad for its consideration and approval.

183. In a meeting of the Upazila Parishad, Chairpersons of the concerned Union and other adjacent Unions and the representatives of the various development related government departments and agencies discuss the proposed subproject. After necessary amendments, if any are made, the Upazila Parishad approves the subproject proposal and it is sent to the District Executive Engineer, LGED.

184. The Executive Engineer reviews the proposal in the context of the district strategies for SSWR development and, if satisfied that the proposal contributes to the development objectives of the District, forwards it to the IWRM Unit of LGED in Dhaka for consideration under available development project

185. From the IWRM Unit, a technical reconnaissance of the subproject site by professional specialists are made when specialists of different disciplines discuss with local farmers and knowledgeable persons at field level to obtain views and opinions of the local stakeholders.

186. Upon recommendation of the reconnaissance team that the proposed subproject has potential for development, a PRA study is undertaken that involves a very extensive discussion with local people of all classes and communities in groups village to village. Objective of the PRA is to assess if there is wide based support for the subproject from local people and if there is any opposition to it from any section or group of people.

187. If the proposed subproject is recommended by the PRA study, a preliminary planning of the required physical works made and costs thereof are estimated, a preliminary assessment of benefits made and preliminary indices for economic viability checked. If the subproject appears, through this preliminary analysis or prefeasibility analysis, to be technically and economically promising, the beneficiaries and other stakeholders are consulted about the physical works that are being planned for the subproject in a large general ***Planning Meeting*** and agreement of the local people on the overall subproject planning obtained. With this agreement on subproject planning and the preliminary technical and economic viability, the Prefeasibility Report of the subproject is finalized and place to DLIAPEC for inter-agency clearance regarding duplication or overlapping.

188. It may be noted that up to this stage, participation of the beneficiaries and other stakeholders in the subproject matters are of consultative nature, not through any institutional platform, but are conspicuously tailored into the development process of the subproject in such a way that the participation is quite intensive.

3.7.3 Institutional mobilization of Beneficiaries and Formation of WMCA

189. As the subproject is cleared by the DLIAPEC, works on detail feasibility study as the *"technical process*" and on establishing institution for local stakeholders' participation as the *"institutional process*" commence simultaneously.

190. The objective of institutional process is to establish a Water Management Cooperative Association (WMCA) as an institution of the local stakeholders of the subproject under the legal framework of Cooperative Act in force in the country. The first step in the institutional process is to form a ***"Organizing Committee*"** and, through it, perform the initial organizing works - information campaigning for beneficiaries to participate in operation and maintenance of the subproject and forming the WMCA, setting up office with books and records, beneficiary listing, membership enrolment, opening Bank Account, and most importantly drafting Bye-Law for the WMCA and holding election of the first management committee of the WMCA.

191. The ***First Management Committee (FMC***) becomes the focal point for a number of key activities:

- Commenting on design of subproject physical works
- Membership enrolment
- Build WMCA capital by share and savings collection
- Appoint Accountant/Cashier and maintain accounts and records
- Apply and obtain registration of the WMCA
- Form Sub-Committees
- Prepare for General Election of the WMCA
- Collecting upfront beneficiary contributions for O&M.

192. It is expected that the WMCA formed through workings of the OC and FMC will be a broad-based and strong water management organization – a platform for all decisions on the management of the subproject. This will include resolving conflicts of interest between different groups that come up time to time. Registration of the WMCA and collection of upfront O&M contribution from the beneficiaries are the two critical activities that are the pre-conditions to signing IA to initiate construction activities of the subproject.

193. The Cooperative Act and Rules framed under it governs registration, supervision and management of operational, financial and legal administration of the WMCAs. Defining aims and objectives of the Association including the methods and manners to achieve them are left to the Association to be framed in a detailed Bye-Law of the WMCA to the extent that those are not contradictory to the provisions of the Act and Rules.

3.7.4 Operation and Maintenance Sub-Committee

194. After handover of the completed subproject to the WMCA, main responsibility of water management in the subproject with the help of the constructed physical facilities - khals, embankments, hydraulic structures (regulators, sluices, WRS, Rubber Dams, irrigation canals, buried pipe irrigation systems, etc) and maintenance of those physical facilities rest mainly on the WMCA. To discharge these two specific responsibilities, the WMCA will need a dedicated Subcommittee - the O&M Subcommittee which will be formed under provision of the Bye-Law of the WMCA.

195. The O&M Subcommittee will have 9 - 12 members with 3 members taken from the elected Management Committee of the WMCA. The remaining 6-9 members will be selected from amongst the general members. It is recommended that these members be selected one from each of the subproject villages for equity. Details of formation and functions of O&M Subcommittee is given in the Guidelines Document ***G8 Guidelines for SSWR Development: Operation and Maintenance of Subprojects.***

3.7.5 Beneficiary Commitment to Operation and Maintenance

196. The only objective for which all the pains and procedures for establishing a capable and performing WMCA are undertaken is that the Operation and Maintenance of the subproject would be good and the subproject would give its planned benefit to its beneficiaries. In real term, this will mean that the subproject beneficiaries and for that matter their institution – the WMCA will own the subproject and be committed for sustainable O&M of the subproject. The following steps will help the WMCA to become committed in this respect:

- Ensuring that the beneficiaries and later the WMCAs understand early in the subproject processing cycle that the subproject infrastructure would be formally handed over to them and that routine operation and maintenance including costs thereof will be their responsibility.
- Obtaining from subproject beneficiaries, formal commitment to contribute in cash and in kind to routine operation and maintenance costs. These commitments are ensured in the IA signed by WMCA, and Executive Engineers, LGED. The O&M costs are currently estimated at 3% for earthworks and 1.5% for structures costs of the subproject. The cost figures is also included in the IA..
- Involving the beneficiaries and obtaining their satisfaction about planning and design of the subproject's component structures.
- Providing the WMCA with copy of Document "**G8 *Guidelines for SSWR Development: Operation and Maintenance of Subproject Infrastructure***" as an all time reference book on operation of water regulating structures of the subproject and conducting routine annual and periodic maintenance of the subproject infrastructure – embankment, khal and hydraulic structures.
- On completion of the subproject works, WMCAs are to be provided with elaborate trainings, referring to the Guidelines Document G7, on operation of the hydraulic structures (opening and closing gates based on water levels on both sides to maintain an optimum water level inside the subproject) and maintenance of subproject infrastructure (assessment of required maintenance and estimate of cost, collection of fund and doing the works in time).
- The WMCA is provided with a *O&M Plan of the subproject* prepared by the FSDD Consultant that includes basic operation schedules of the gates of all hydraulic structures of the subproject over the crop seasons of a year and dimensions and other parameters of different physical works that form basis of estimate of possible maintenance works. The WMCA will need to update and adjust the schedules of operation of gates and actual maintenance needs on the basis of above O&M trainings they receive, experience from 1-year joint O&M with LGED and actual on-field requirements.
- There is provision for a LGED-WMCA joint O&M of each subproject after its hand-over to the WMCA. This provides the WMCA with a sort of on-the-job training on O&M of the subproject.
- Assisting the WMCA in the preparation of agriculture and fisheries development plans. SSWRD projects usually provide Agricultural and Fisheries Facilitators at Districts to provide necessary technical assistance to WMCAs and also to local LGED offices.
- After the project is closed, WMCAs will receive technical support from Upazila Officers of DAE and Fisheries Department with cooperation from LGED.

- Planting trees on embankments, which provide some protection to embankments from erosion as well as resources for generating some income to the WMCAs and the care taking poor women of the locality.

3.8 Gender Perspective in SSWRD Subprojects

197. As SSWRD subprojects are related to water and agriculture, women have sufficient scope to contribute in subproject matters. SSWRD projects envisage that at least one-third of members of the WMCAs, both general members and members of the Management Committees, should be women. Local stakeholders should encourage womenfolk to become general members of the WMCA and, in particular, family-head women should come in the MC of the WMCAs. LGED field officers and project staff, when available, will assist the stakeholders in this respect..

198. To encourage women's participation in the subproject matters, women members should be included in the Organizing Committee.

199. The principle of equal employment opportunity will be followed in all matters of the subproject and WMCA. Equal wages for the same work and equal scope of working in LCS will be followed.

200. Special training program shall be arranged for women members of WMCAs to start income generating activities that will help rural women to raise family income. The women beneficiaries may get training on seed production and processing, poultry farming and processing, seasonal vegetable production, pond fish culture, etc. WMCA would be encouraged to provide micro-credit to the trained women for IGA.

201. WMCA will ensure that poor women groups are engaged in maintenance works of subprojects like embankment maintenance, caretaking of tree plantations, etc.

3.9 Financial and Economic Analysis

3.9.1 Introduction

202. Each subproject shall be subjected to both financial and economic analysis to:

- Determine potential impact of the subproject on local economy.
- Establish potential impact of the subproject on national economy.

203. The procedure and model used in economic analysis of subprojects of LGED's earlier SSWRDPs are based on Guidelines of Asian Development Bank for Project Appraisal, 1996 and the same shall continue to be followed for financial and economic analysis of subprojects under future projects unless improvements are specifically justified.

204. The economic appraisal model uses a Microsoft Excel Spreadsheet Program containing macros and user assistance dialogues as required. The Program's input requirement is data on costs including O&M costs, land use, socio-economics, agriculture, fisheries, other subproject approval requirements and its outputs are tables and chart displays including sensitivity analysis of the computed IRR.

205. The subproject appraisal Program is available with IWRMU (P&D Section) and PMO-Project Consultants of ongoing projects. FS consultant firms of ongoing projects are also provided with the program for use in their works.

3.9.2 Investment Costs (financial)

206. Investment cost of subprojects are broken down into the following categories:

- Engineering works
- Ancillary facilities
- Supporting works
- Physical contingency
- Price contingency
- Administration and Engineering

207. Physical works that result from engineering analysis and feasibility level design shall be estimated by using the LGED Schedule of Rates in force to derive the cost of engineering cost. The engineering works will generally include items such as hydraulic structures (regulators, sluices, water retention structures, Rubber Dams, weirs, aquiducts, syphones, irrigation canals(pucca), buried PVC irrigation pipelines, etc), other structures (WMCA Office buildings, culverts, bridges, etc), earthworks associated with constructing embankments, excavating drainage khals, etc. Costs of these main works may be guided by unit costs - cost per km of khal or embankment or buried irrigation pipelines, cost per unit of regulator/sluice/WRS of required sizes (1-vent, 2-vent, etc) that can be obtained from MIS for the recently completed projects. Nevertheless, adjustments to the above derived costs based on engineering judgement of the conditions of the concerned subproject will be necessary.

208. If design of works (sections of khals and/or embankments, sizes of regulators, sluices, WRS, etc) are desired for more realistic estimate of costs, Spreadsheet Design Programs available in Guidelines Document ***G6: Detail Design of Subproject Structures*** may be used to have the designs done.

209. As a yet another alternative to have feasibility level design of structures, design Tables have been reproduced from the previous *Standard Design Catalog* (not in use now) and given in ***Exhibit G4-H.***

210. Ancillary facilities include costs associated with subproject components such as buildings, equipment and machinery, and land acquisition. Costs of these works shall be based on engineering estimates.

211. The costs of supporting activities for agriculture, fisheries, livestock, socio-economic, and economic development and extension programs/services including demonstrations are estimated at 3% of the total costs of engineering works and ancillary facilities. Physical contingencies are estimated at 7% of the total base costs. Price contingencies are estimated appropriately based on the current rate of inflation (in recently completed/ongoing SSWRD Projects, 5% price contingency were used). Administration & Engineering design costs are estimated at 5 % of the total base costs.

3.9.3 Operation and Maintenance Cost (financial)

212. Costs estimates for operation and maintenance include provision for engineering works as well as ancillary facilities. Annual operation and maintenance costs shall be estimated at:

- 1.5% of structure cost,
- 3% of earthworks cost,
- 5% of submersible embankments cost,
- 10% of fish screen (made of bamboo) cost,
- 7% of equipment cost,
- 0.5% of total cost (as miscellaneous expenditures).

3.9.4 Economic Costs

213. Conversion factors to convert financial costs of usual investment cost components into economic costs are given in the appended **Exhibit G4-G, Table G4-G.2.**

3.9.5 Crop Budgets

214. Financial prices for agricultural inputs and outputs are initially derived for the Project area by averaging district-level prices provided by Directorate of Agricultural Marketing, Ministry of Agriculture and adjusted with field prices during study of an upcoming project.

215. Calculation of economic farm gate prices of internationally traded imported and exported commodities are shown based on prices of inputs and outputs in ***Table G4-G.4***. For non-traded commodities, economic prices are calculated by using conversion factors adopted from recent studies of water resources development projects that are conducted using Flood Action Plan Guidelines for Project Assessment. **Exhibit G4-G, Table G4-G.3** gives such conversion factors which can be used for locally traded commodities.

216. Based on the above, conversion of financial prices to economic prices of agricultural inputs and outputs are given in ***Tables G4-G.5*** and ***G4-G.6*** respectively of the appended ***Exhibit G4-G***. Upcoming projects will update the figures in the Tables as would be needed.

217. Based on the financial and economic prices of agricultural inputs and outputs from above Tables and yield and input use data of different crops given in ***Table G4-G.1 (***part ***A*** and part ***B)***, standard crop budgets on per hectare basis is shown in ***Table G4-G.7*** (part ***A*** and part ***B***) of the appended ***Exhibit G4-G***. Upcoming projects will update figures in the Tables using respective field data and secondary data of the time concerned.

3.9.6 Fisheries Budgets

218. Fisheries budgets have been prepared for capture fisheries in perennial water bodies and in floodplains. Pond aquaculture is judged not to be significantly influenced by the investments under the Project and should not be in the analysis. Basis for fisheries analysis are given in ***Section 3.4.3.*** Details of economic analysis based on 1 ha fisheries are provided in ***Table G4-G.8a*** for perennial water bodies and ***Table G4-G.8b*** for floodplains in ***Exhibit G4-G***. The pre-and post-subproject financial and economic unit values corresponding to the given yields are shown below which is the output format of fisheries production in the economic analysis model. The model will calculate production values with input of project specific area data.

	Pre-Subproject						
				Unit Value		**Production Value**	
Habitat	**Area (ha)**	**Yield (kg/ha)**	**Production (t)**	**Financial (Tk/ha)**	**Economic (Tk/ha)**	**Financial (Tk)**	**Economic (Tk)**
Floodplain (F2+F3)	0	50	0	2,275	68	0	0
Perennial Water Bodies	0	220	0	2,250	3,601	0	0
Totals	0		0			0	0
	Post-Subproject						
				Unit Value		**Production Value**	
Habitat	**Area (ha)**	**Yield (kg/ha)**	**Production (t)**	**Financial (Tk/ha)**	**Economic (Tk/ha)**	**Financial (Tk)**	**Economic (Tk)**
Floodplain (F2+F3)	0	25	0	1,138	-284	0	0
Perennial Water Bodies	0	110	0	-240	845	0	0
Totals	0		0			0	0

219. Financial prices for fish products, as well as operating costs and labour are based on field data collected for the project studies and review/optimized by PMO-Project Consultants. Since these are not internationally traded commodities, the conversion to economic prices was made using standard conversion factors of 0.87 for fish products and operating costs, and 0.75 for labour.

3.9.7 Assumptions in Financial and Economic Analysis

220. The financial and economic analyses are based on a number of assumptions. The key assumptions are:

- Subprojects have a life of 30 years (including construction). The "present" and the "future without subproject" conditions of the subproject areas remain the same.
- Full post-project benefits are achieved within three years of completion of subproject infrastructure (phasing 50%, 75%, and 100%).
- Indirect benefits are not included in benefit stream.
- The exchange rate of US Dollar is taken as the IP rate existing in the Bank's auction market during project study. This may be reviewed from time to time. This exchange rate is assumed to represent real opportunity costs of capital.

3.9.8 Appraisal Model's Output Tables and Charts

221. With the requisite inputs of costs and benefit elements based on discussions in the foregoing paragraphs, the model gives ***11 Tables*** and ***4 Charts*** as the results of financial and economic analysis and appraisal of the subproject. *Table-1, Chart-1* and *Table-2, Chart-2, Chart-3* depict respectively Land Types and changes in Land Use in the subproject while *Tables 3 to 10* presents financial and economic analysis including cash flow and FIRR and EIRR for the assumed 30-year life period of the subproject.

EXHIBITS

Exhibit G4-A: PROCEDURE FOR FIELD INVESTIGATION AND PREPARATION OF PREFEASIBILITY REPORT BY FEASIBILITY STUDY CONSULTANTS

A. PREPARATION FOR FIELD INVESTIGATION

1. Prior to field investigation of a proposed SSWRD subproject the WR Planning Engineer, as the Team Leader of the FS Consultant Team, must have completed the following:

- Review subproject proposal
- Obtain primary information of the subproject – Form-1, Form-2 and Form-3 along with the GIS based preliminary subproject Index Map from PMO. The Index Map may be checked for the subproject boundaries and improved by adding land elevation contour lines from 4" to 1 mile irrigation planning maps. This preliminary subproject Index Map will be used in the field investigation;
- Identify the nearest relevant Water Level stations and determine statistical and historic water levels at the subproject site;
- Check the problems stated in the subproject proposal and pre-screening reports against the topographic and hydrologic data (ground elevations from the contour map and the available water level data);
- Review the proposed type of interventions and possible extent of solution to the problems;
- Check possible impacts of the interventions i.e., elimination/reduction of pre-monsoon or monsoon flood, improvement of drainage – pre-monsoon / early monsoon drainage or removal of post-monsoon water logging, improvement in water availability for irrigation or irrigation facilities;
- Demarcate on the above Subproject Index Map the preliminary subproject gross benefited area. The benefited area may include area presently affected by flood, prolonged inundation, water logging or irrigated area including new area likely to come under irrigation. Depending on the subproject type the gross benefited area may or may not coincide with the subproject area or catchment area.

2. On completion of the above tasks, the WR Planning Engineer should apprise the other team members - Agronomist, Fisheries Specialist, Sociologist and Environmentalist the preliminary information about the subproject in group meeting:

i. Present conditions (topography, existing infrastructure, water management conditions and problems)
ii. Proposed interventions, and
iii. The expected impacts.

Each team member should take note of the above information and have copies of the preliminary Subproject Index Map and other relevant information – Form-1, Form-2 and Form-3. The Sociologist/Socio-economist will use a copy of Upazila Base Map for identification of the subproject villages and mouzas which are identified by J.L. No. (Jurisdiction List Number). If necessary the team members should be given time to collect necessary secondary data and prepare for the subproject field inspection. In case of the first field investigation visit of the team or several members of it, the team may seek a brief orientation from the PMO-Project Consultants.

3. For efficient use of time and to have better interaction, it is advised to conduct the field investigation by the team jointly. However, in the field, some member like the Sociologist and environmentalist may conduct their own program - holding group discussions etc separately. Usually, a 2-4 days time would be required for the field investigation depending on size and complexity of the subproject.

4. The FS Consultant's field inspections should follow standard rules and procedures, which should be known to all the involved parties and individuals; these are as follows.

i. The Consultant informs the LGED District Executive Engineer, with sufficient lead time, by telephonic discussion and followed by FAX message, the following information:

- Date of inspection (provide day and hour of arrival at the Executive Engineer's office)
- Name of subproject(s) to be inspected with names of Upazilas and Unions
- Name of Consulting Firm
- Names and designations of the inspection team members
- Additional information about the subproject that the team may require from the District LGED Office prior to commencement of the field inspection and assistance like accompanying staff, etc.

The above information should also be given to the Upazila Engineer by phone. The followings are expected to happen in follow up:

i. The Executive Engineer informs the Upazila Engineer about the Consultant's field inspection and instructs concerned district level project staff (Water Resources Engineer, Community Participation Officer) to collect necessary documents and be ready to accompany and assist the Consultant team.

ii. The Upazila Engineer instructs Upazila level project staff (if available) and CO to make preparations for the Consultant's field visit and accompanying them.

iii. The project staff work together and organize presence of Union Parishad Chairperson and Members of the area during visit of the Consultant team.

B. CONDUCTING FIELD INVESTIGATION

Courtesy Meeting at Local LGED Offices

5. On arrival at the District, the multidisciplinary field investigation team of consultants will have a short courtesy meeting with the Executive Engineer, LGED and District level project staff (WRE, CPO). The team will explain the purpose of the visit and seek for support as may be necessary. The project staff will accompany the team.

6. At the Upazila Office, the Consultants team accompanied by District level project staff will discuss Upazila Engineer and his staff about their investigation program. The Upazila level project staff (SAE/Construction Supervisor) will attend the discussion and join the field works.

Subproject Field Investigation

Objective of the field investigation is to verify the existing problems, which are listed in the subproject proposal, to identify new/additional problems if any, and to obtain more refined information and data that will be useful in conducting feasibility analysis and design of the subproject.

7. The investigation should start at the lowest point in the subproject area; the outfall channel or structure point in drainage and flood management subprojects. Starting field inspection from the lowest point will allow immediate verification of flood problems, which should be most serious in the lowest area and less serious or diminish in upper areas.

8. The WR Planning Engineer verifies in the field the subproject catchment boundary by walking around the subproject boundary previously defined from the maps. Any culverts and bridges must be marked on the Index Map with dimensions and direction(s) of flow, depth and dates of maximum and minimum flows.

9. The Consultant team members will interview people at suitable locations to obtain specific data and information according to their disciplines. It is important that the Consultant's team members introduce themselves to every person they ask questions.

10. The Sociologist and Fisheries specialist will interview people and collect information from selected villages and households using the Fisheries Questionnaire. The Fisheries Specialist should ask people about existence of open water fisheries like flood plain fisheries, which is defined by more than 0.9 m depth of flooding. This information is vital for cross checking with agriculture and engineering conditions.

11. The WR Planning Engineer and Agronomist will ask farmers inside and also outside of the subproject, about the current problems and their ideas about possible solution:

- The Agronomist collects information about cropping patterns, yields and constraints like crop damage by floods and drought. He should note dates of floods and mark on the map extent of floods, water logging and drought affected areas.
- The WR Planning Engineer collects information about water related problems, their causes, origin and possible solutions.

12. There are 3 basic types of water related problems:

- Flood
- Drainage, and
- Drought or shortage of water

Depending on topography and hydrological conditions these problems can appear as a single problem or as a combination of two or all the three problems.

13. For efficient use of resources, the collection of field information should be grouped into the following three categories of problems and the questions asked should be specific.

Investigation of Flood Problems

Flood management subprojects require rehabilitating/upgrading/construction of embankments or road-cum-embankments and construction of regulator/sluice structures to check flood inflow and drain excess water (local runoff from rainfall) from the protected area. In SSWR subprojects regulator / sluice structures are integral part of a FM intervention.

<u>Extent and levels of floods</u>

14. The term Flood refers to inundation of land by water of external or mixed origin; water coming from upper area and accumulating in lower area of the same catchment is also considered as flood. Typically the information to be collected includes:

- Pre-monsoon maximum flood level - flood that damages Boro crops before harvest (ask people to show water marks of this flood on houses, roads/embankments, bridges, parmanent posts, trees, etc.).

- Extent of area in the field that is inundated during Boro crop season.
- Monsoon season maximum flood level
- Monsoon season average flood level
- Extent of deep monsoon flooding, i.e., limit of area in the field that remains inundated and no crops can be grown.

15. Limits of floods identified in the field should be marked on the subproject Index Map with contours, from which approximate flood elevations can be estimated. The flood elevations will be determined later in more detail by surveying the flood-water marks (mPWD) during topographic survey.

<u>Source of Floods</u>

- Backflow through a khal connecting the subproject with adjacent or downstream river
- Overland flow from upper catchment
- Overtopping embankments and roads
- Source of the overland/overtopping flow
- What is the water level in the adjacent river at the time of subproject flooding (above or below the water level in the subproject; give approximate difference in cm or meters)

16. Local people should be asked about points, direction and dates/month of flood entry, and these should be marked on the Subproject Index Map.

<u>Required Flood Prevention Works</u>

17. Local people should be asked about their ideas on how to protect the area from floods:

- Construction of new flood embankments are not encouraged and therefore suitable alignments along existing village roads should be preferred. However, in unavoidable situations, short lengths of new construction to connect existing road alignments may be accepted.
- If re-sectioning of road or existing embankment involved, mark sections overtopped by high floods, and depth of overflowing water.
- Required structures – check the sites and make notes on required access road, link dykes or other works like channels for local drainage or depressions cut off by local dykes.

#

Investigation of Drainage Problems

Generally drainage subprojects comprise earthworks like re-excavation of khals and there is no need for embankments. Hydraulic structures are not usually required in drainage improvement subprojects unless specially needed to prevent over-drainage of beels, etc.

Drainage problems relate to prolonged inundation in local depressions and flat lands by rain water of local (subproject boundary) or external origin due to lack of or insufficient drainage facilities like channel(s) with too small longitudinal slope or reduced flow section. The channel flow section can be reduced by channel siltation, accumulation of debris, water hyacinth, construction of artificial cross-dams or improperly designed culverts and hydraulic structures.

Insufficient drainage is indicated when water level in the affected area remains high while water level in the outfall channel (khal or river) is falling down.

Drainage Problems

18. There are two types of drainage problems
    i. drainage congestion (external) and
    ii. water logging (internal).

Drainage congestion occurs when the capacity of external outfall channels is not sufficient to evacuate excess water from the subproject area. Generally removal of drainage congestion involves re-excavation of channels (rivers or khals) outside the subproject boundary.

Water logging occurs when the capacity of internal channels or drainage system is not sufficient to drain the excess water from the subproject area. All obstructions of flow including too small structures will cause water logging. Removal of water logging requires excavation/re-excavation of channels or construction of additional structures within the subproject.

[In practice, in the initial stages of subproject preparation including PRA investigation, drainage problems may be confused with flood problems as both result in inundation of land. Therefore, it is important that the Consultants collect relevant information and data necessary for proper identification of the existing problems].

19. Questions to be asked to local people should include:

- When land inundation is a problem?
  - in pre-monsoon season
  - in monsoon season
  - in post-monsoon season
- Identify in the field areas inundated during pre-monsoon
- Period of inundation (dates and days)
- What is the source of inundation water
  - local rain
  - upstream overland inflow
  - backflow from downstream khal/river
- What is the water level in the outfall river/khal at the time of inundation?
  - the same as in subproject? - Yes/No
  - if lower, by how much ? (m)
- Is the area inundated during monsoon season?
- What is the water level in the outfall river/khal at the time of inundation?
  - the same as in subproject? Yes/No
  - if lower, by how much (m)
- If the problem is delayed post-monsoon drainage ?
  - average date when water drains from the area
  - date when land preparation is required for planting Boro rice

Investigation of Drought Problems

As drought or shortage of water in the dry season prevails all over Bangladesh, there is no need for verification of the problem; the field investigation should rather be directed entirely on finding means to facilitate irrigation water availability.

Two types of subprojects are implemented under the SSWRD projects to alleviate drought: Command Area Development (CAD) and Water Conservation (WC) subprojects.

Command Area Development (CAD) Subprojects

[CAD subprojects include improvement and/or extension of irrigation systems and irrigation area. Irrigation water is lifted from a river channel with perennial flow by means of pumps (stationary or floating pumps)]

20. Field investigation for CAD subprojects generally comprises:

- collection of data on flood water levels during monsoon and minimum flow and water levels in the source river during the dry season
- inspection of existing irrigation systems and the constraints with a view to improve/expand conveyance of irrigation water, and
- inspection of additional area to be brought under irrigation; availability of irrigable land, required new canals and canal structures, availability of land for the works availability of adequate water to lift.

Water Conservation (WC) Subprojects

[The WC subprojects are designed for retention of water in a khal (drainage channel) at the end of monsoon. By heading-up water in the channel upstream from the structure the out flow from the subproject is reduced or terminated and water, that otherwise would drain out unutilized, is used for irrigation of Rabi and Boro crops. Usually, the retained water is lifted from the channel into adjacent fields by LLPs. With suitable topography the headed up water may be diverted for gravity irrigation downstream from the structure.

A continuous minimum flow in the channel throughout the dry season is the primary requirement for a successful WC subproject. Ideally, if the channel flow dries out by the end of February, there may be not enough water in the storage of the subproject for full irrigation of Boro crops, even with enlarging storage capacity by re-excavation of the channel. However, people may be interested for partial irrigation using the stored water and the rest using ground water using tube wells. Also, return flow from ground water irrigated upper lands adding up to the storage is also counted in many cases (large areas of ground water irrigation).]

21. Field investigation for WC subprojects comprises:

- verification of the catchment boundary upstream from the proposed structure site
- inspection of the proposed structure site (note khal dimensions, channel stability, bank erosion, dimension of existing bridge or culvert on the khal nearby)
- minimum dry season flow (measure depth, area and velocity of flow (by float method) to determine discharge)
- maximum flood water level and channel section to estimate maximum design discharge in case the catchment area cannot be defined (missing map coverage of hilly area or catchment is beyond international border) and also as a check of catchment calculated discharge.
- longitudinal slope of the khal to assess if the conserved water will extend up to short distance only when after construction of the now proposed structure, people may ask for another structure upstream i.e. the subproject may need cascaded water retention with several structures if land slope is steeper.

22. During the field inspection the WR Planning Engineer should obtain enough information about the state of the subproject khal(s) to determine if re-excavation is needed or not. He should mark on the index map the required surveys.

23. The WR Planning Engineer should assess if a cascaded water retention is required for the subproject.

B.3 Completion of Field Investigation

24. Before the field inspection is completed the WR Planning Engineer has to make sure that he has collected enough information to

i. prepare a plan of all the required physical works for the subproject,

ii. carry out calculations to assess approximate size of the works (khal and embankment lengths and sections, number and size of structures) and their tentative costs,

iii. plan the required engineering surveys and give precise instructions to the surveyor how to conduct and what to survey.

25. As a team leader the WR Planning Engineer will exchange information with other team members about his findings and proposed changes if any about the type of intervention and the required works. The Agronomist should have obtained adequate data and information to be able to estimate an approximate annual return from agriculture. The other team members should also be satisfied about their investigation and collection of data/information.

26. On completion of the field investigation, the team will meet the District Executive Engineer, LGED and project staff in a short de-briefing session on the investigation and preliminary findings.

27. After completion of the field inspection and back to office, the team will hold discussion on preparing the Prefeasibility Report and submit their respective write-ups. The WR Planning Engineer will update the Index Map of the subproject by incorporating information from field investigation (natural physical features and existing infrastructure, boundaries - subproject area, catchment area and benefited area, interventional works considered necessary, etc). He will also prepare draft of a Prefeasibility Report with contribution from all the team members following the outline given in ***Exhibit G4-B*** appended to this document.

28. The improved subproject Index Map and the draft of the Prefeasibility Report prepared by the FS Consultant based on their field investigation will be reviewed by the PMO-Project Consultants and discussed with the FS Consultant team taking into consideration the findings and recommendation of the Reconnaissance and PRA Reports. The draft Prefeasibility Report along with the draft Index Map will be finalized through this discussion including modifications if any for holding the Planning Meeting.

Exhibit G4-B:
TABLE OF CONTENTS OF PRE- FEASIBILITY REPORT

(With Text Guidelines)

1. Introduction: (Information on current SSWRD Project, subproject proposal by UP and recommendation from Upazila Parishad with dates, screening, reconnaissance by IWRMU, LGED with dates and taking up for detail study for technical and economic viability)

2. Subproject Overview: (Location - by mouza, Union, Upazila and District; Development Concept – main water management problem and approach to solve or mitigate it; Category and Type of Subproject; Interaction with existing large WM projects, if any; etc)

3. PRA : (PRA done by firm with dates and outcomes, particularly on beneficiaries' commitments and special comments /conditions, if any)

4. Field Investigation: (Visit by FS firm's Consultant Team on dates, main activities done, important observations, etc)

5. Subproject Planning: (Physical works planned are listed with names, quantities and approximate costs; showing in subproject's Index Map)

6. Subproject Benefit: (Agricultural Benefit by seasons, crops, land under the crops, production and returns; Fisheries benefit – positive or negative)

7. Economic Appraisal: (EIRR, B-C ratio based on the approx. cost and benefit)

8. General Observations on Social and Environmental viability:

9. Recommendation:

Exhibit G4-C:
USUAL PROBLEMS AND PHYSICAL WORKS REQUIRED FOR DIFFERENT TYPES OF SUBPROJECTS

Subproject Type	Present (pre-subproject) Problems		Possible Causes / Origin of Problems	Usual Physical Works Required
	Hydrological	Agricultural		
1. Flood Management (FM)	• Pre-monsoon river flood inundates the area. • Monsoon river floodwater enters the area fast; frequent/repeated inundation by peak floods. • Deep flooding in monsoon.	• Inundation and damage of Boro rice before or at harvesting. • Inundation prevents plantation of Aus and Deep Water Rice (DWR), or damage young Aus or DWR seedlings. • Damage of mature Aus in early monsoon; fast inundation and damage of young T. Aman rice. • Delayed transplantation of T. Aman; transplantation required more than once; late transplantation reduces yield • No crops or only DWR can be grown during monsoon.	• Short duration and high peak floods in small and medium flashy rivers with hilly catchments. • Multiple peak floods in medium to large rivers in northern part of the country. • Vast floodplains of very large rivers in the country. • High intensity rainfall in upper catchments.	• Construction of flood embankments. • Re-sectioning / strengthening of existing flood embankments or road-cum- embankments. • Construction of sluices with automatic flap gates. • Construction of regulators with vertical lift gates.
2. Drainage Improvement (Dr)	• Delayed/slow drainage of pre-monsoon rain accumulated in lower lands. • Delayed/slow drainage of monsoon runoff from upper parts of subproject basin. • Water logging in land depressions in pre- and	• Inundation and damage of Boro rice before or at harvesting. • Inundation and damage of Aus or young Aman rice. • Excess water prevents land preparation and plantation of Kharif-1 crops. • Water remaining in the field prevents land preparation and	• Insufficient capacity of internal drainage system due to narrowed or silted internal drainage channels. • Insufficient capacity of structure constructed over drainage channel; culvert or hydraulic structure with too high invert level or structure too small.	• Re-excavation / excavation of internal drainage channels (ditches, khals). • Construction of additional drainage structure (bridge, culvert, sluice/regulator or weir). • Excavation of drainage-link channel. • Re-excavation/dredging of outfall channel, if the channel is adjacent

Exhibit G4-C

Subproject Type	Present (pre-subproject) Problems		Possible Causes / Origin of Problems	Usual Physical Works Required
	Hydrological	Agricultural		
	post-monsoon seasons. • Drainage congestion; water does not drain or drains very slow from the subproject area.	plantation of Rabi crops.	• High water level in outfall drainage channel/river with sufficient section. • No drainage channel in the area. • Silted outfall drainage channel.	to the subproject. It may not be feasible under the project if channel is large or outside subproject.
3. Tidal Irrigation (TI)	• Tidal water (fresh water) cannot propagate deep inland through khals in dry season	• Cultivation of Boro rice crop suffers and at times remains only rain fed in fresh water tidal areas.	• Bed of tidal khals became high due to silting up of khals and so tides can go only short distance inside.	• Re-excavation of tidal khals to facilitate tidal water reach further inland to cover more land under irrigation.
4. Water Conservation (WC)	• Shortage of water and drought conditions during winter and pre-monsoon season. • Water drains fast at the end of monsoon and cultivable lands experience drought. • Shortage of water during long rainless period in later part of monsoon season.	• Rabi and Boro crops suffer drought damage or crops can be grown only in small area. • Soil residual moisture level falls fast and there is not enough water to grow Rabi crops and wheat. • Shortage of irrigation water for Boro rice cultivation in areas where groundwater is not available. • Aman rice crop suffer shortage of water during dry spells in the later part of monsoon –require supplementary irrigation.	• Steeper gradient of drainage khals drains area quickly. • Rainwater drains fast from the area due to high land slope. • Long dry spells (rainless days) towards later part of monsoon – as rainfall reduces.	• Construction of water conservation facilities like gated water retention structure (WRS), elevated sill fixed weirs, drainage regulators/sluices provided with slide gates for retention of water in the channels; • Re-excavation of khals to increase water storage and facilitate water availability for longer time.
5. Command Area Development (CAD)	• Shortage of water and drought conditions during winter and pre-monsoon season. • Drought condition in long rainless days during monsoon season. (in northern	• Non-availability of irrigation water for Boro rice cultivation though land remains fallow. • Yield of Aman rice reduces due to lack of supplementary irrigation in the later part of monsoon when crop is in flowering stage.	• Existing irrigation system is poorly performing due to loss of water, less irrigation efficiency, obstruction to take irrigation water further, or too little pumping capacity, etc	• Construction of lined canals, buried pipelines, structures for water distribution, cross drainage, pump stations, headwater tank, etc. • [Sufficient water at the source river should be checked.]

Exhibit G4-C

Subproject Type	Present (pre-subproject) Problems: Hydrological	Present (pre-subproject) Problems: Agricultural	Possible Causes / Origin of Problems	Usual Physical Works Required
	parts of country) requiring supplementary irrigation.			
6. Flood Management and Drainage (FMD)	• Inundation by river flood in pre-monsoon, monsoon seasons • Slow and delayed drainage following heavy rain or river flood inundation. • Pre-monsoon and /or post- monsoon Water logging in low lands	• Flood damage of Boro rice; grows only local variety Boro; low land remains fallow. • Flood damage of Aus and/or Aman rice; land remains fallow. • Late planting of Rabi crops; crops can not be cultivated.	• High river stages compared to subproject land elevations; • Reduced capacity of drainage khal system • Lack of drainage channel from isolated lowlands.	• Construction of / upgrading of roads to flood embankments. • Excavation / re-excavation of khals. • Construction of sluices / regulators.
7. Flood Management, Drainage and Water Conservation (FMD&WC)	• Pre-monsoon and/or monsoon flood inundation; • Slow/delayed drainage following heavy rain or river flood inundation; • Pre-monsoon and /or post- monsoon Water logging in low lands • Shortage of water in post monsoon and dry seasons.	• Flood damage of Boro rice. • Flood damage of Aus and/or Aman rice; land remains fallow. • Late planting of Rabi crops. • Boro crops suffer from water stress (droughty crops). • Expansion of Rabi and Boro crops not possible for shortage of water; crops cannot be cultivated.	• High river flood stages in relation to subproject land elevation. • Inadequate drainage facilities. • Lack of drainage channel from isolated lowlands. • Lack of or insufficient facilities for storage or control of water outflow.	• Construction / upgrading road to flood embankments. • Re-excavation of drainage channels. • Construction of sluices or regulators equipped with slide gates designed for retention of water.
8. Drainage and Tidal Irrigation (Dr& TI	• Delayed and slow drainage during pre-monsoon and post-monsoon. • Water logging in land depressions in pre- and post-monsoon seasons.	• Flood damage of Boro crops; late or no planting of Kharif-1 crops. • Late planting of Rabi crops or crops canot be cultivated. • Cultivation of Boro rice crop suffers and at times remains	• Silted up drainage khals. • Lack of drainage channel from isolated lowlands. • Bed of tidal khals became high due to silting up of khals and so tides can go only short distance inside	• Re-excavation / excavation of internal drainage channels (ditches, khals). • Excavation of drainage-link channel • Re-excavation of tidal khals to facilitate tidal water reach further

Exhibit G4-C

Subproject Type	Present (pre-subproject) Problems		Possible Causes / Origin of Problems	Usual Physical Works Required
	Hydrological	**Agricultural**		
	• Tidal water (fresh water) cannot propagate deep inland through khals in dry season	only rain fed in fresh water tidal areas		inland to cover more land under irrigation
9. Drainage and Water Conservation (DR& WC)	• Delayed and slow drainage during pre-monsoon. • Delayed and slow drainage during post-monsoon. • Shortage of water in winter season.	• Flood damage of Boro crops; late or no planting of Kharif-1 crops. • Late planting of Rabi crops or crops canot be cultivated. • Drought damage of Rabi and limited area or droughty Boro crops; crops cannot be grown	• Silted up drainage khals. • Lack of drainage channel from isolated lowlands. • Lack of or insufficient facilities for storage or control of water outflow from subproject.	• Excavation / re-excavation of drainage channels. - Reconstruction or construction of additional drainage sluices. • - Construction of gated water retention structure (WRS) and / or providing sluices/regulators with vertical slide gates.
10. Command Area Development and Drainage (CAD&DR)	• Shortage of water and drought conditions during winter and pre-monsoon season. • Water logging in lower parts of subproject benefited area.	• Growing of crops during winter is not possible without irrigation. • During pre-or monsoon season crops are damaged due to water logging. Slow and late drainage in post-monsoon limits cultivation of Rabi crops.	• Silted up drainage facilities. • - Lack of drainage channel from isolated lowlands. - General shortage of water for cultivation or increase of area under Boro rice.	• Construction / re-construction of irrigation water delivery and distribution systems like lined canals,etc. and distribution structures, • - Improvement of drainage system (excavation / re-excavation of drainage channels)

Exhibit G4-D:
GUIDELINES FOR CONDUCTING ENGINEERING SURVEY OF SSWRD SUBPROJECTS

A. Reference BM and Transfer of BM Value to Subproject TBM by Fly Level Survey

1. Reference BM

All survey works for SSWRD subprojects must be done with Reduced Levels (RL) referring to Public Works Datum (PWD) in meter units. This is required because the surveyed levels are used for design of interventions like embankments (top level), khals (bed level), irrigation canals (supply water level), regulators/sluices/dams (invert level, water retention level), etc in relation to ground levels and water levels records that are available with reference to PWD. Therefore, to start a survey work, it is necessary to look for and find out a reference Bench Mark (BM) with correct RL with reference to PWD in meter unit (mPWD). For practical purpose, such a BM may be (i) a BM Pillar/Monument established by the Survey of Bangladesh (a large number of such BM Pillars have been established by SOB all over the country with RL values inscribed therein – list of the BM Pillars are public and usually available with survey firms and one of which should be available nearby on search) or (ii) the known RL value of some critically important point (invert level, crest level, etc) of an existing permanent water management structure (regulator, sluice, weir, dam, etc) that are known to be built with dependably correct RL with reference to PWD.

2. Transfer of RL from Reference BM to a TBM at Subproject Site by Fly Level Survey

The RL value of the reference BM shall be transferred by Fly Level Survey to the subproject site at a location near its main structure (regulator, sluice, dam, pump station) and kept on a Temporary Bench Mark (TBM) which may be a point on an existing permanent structure distinctly marked with color and specifically described in the Level Book or a permanent TBM Pillar established kept protected near the construction site.

The route followed during the fly leveling survey shall be indicated and defined by drawing a sketch map of the survey route in a page of the Level Book with names of places along the route. TBM points with RL value written and marked by color shall be kept at different locations along the route (preferably about every kilometers) and locations of all such TBM points and the RL values shall be clearly described in the Level Book and marked in the sketch map prepared so that the TBM values can be checked during back check survey and also during checking of the BM transfer survey any time later, if necessary.

3. Back Check Fly Level Survey and Correction of Minor Differential Error

After establishing RL on the TBM at the subproject site as described above, a back fly level survey shall be done up to the original BM to check correctness of the transferred TBM value. If any error is found during the back check, standard methodology of correction shall be adopted. For error up to 300 mm, method of average is to be used – half of the error is to be distributed proportionately with distance between the BM and TBM and accordingly revise the RL values of the subproject TBM and all the intermediate TBMs. If the error is larger, a fresh survey of BM transfer including back check is to be undertaken. The correction calculations shall be shown in the Level Book.

4. Map and Records of Fly Level Survey Work

Based on the Level Book hand sketch prepared during the BM transfer survey, a map showing the Reference BM – its location and description including the RL value, the route of fly leveling survey, the locations and descriptions of TBMs with RLs kept along the route and at the subproject site shall be prepared in a standard drawing sheet and included in the Album of Drawings for record and future reference.

B. Survey of Khals

5. Sketch Plan of Start Point and Left/Right Bank Delineation

(a) Survey of a khal shall be started from its outfall and proceed upwards. The start point of the khal survey shall be the point at the crossing of khal center line and the bank line of the outfall khal. The start point shall be referenced on ground by distances from two permanent reference objects nearby and considered at Ch 0+000.

(b) For the main khal, a hand sketch showing plan configuration of the main khal and the outfall river/khal (covering 200-300 m on both upstream and downstream) at the outfall place indicating direction of flow, bends, bank erosions, etc and the north direction shall be drawn on the left hand page of the Level Book before starting the survey. The start point shall be indicated in the sketch map along with the reference objects. For branch khals, the hand sketch is not necessary.

(c) The left and right banks of the khal shall be indicated in the sketch map with reference to the direction of flow of the khal i.e. the surveyor shall look along the direction of flow of the khal and call the khal bank on his left hand side as the “left bank” and the khal bank on his right hand side as the “right bank”. The surveyor will follow this rule always during survey of khals.

6. Cross-Section of Outfall Channel

(a) Three cross-sections of outfall khal/river shall be surveyed – one at the outfall point (start point) of the khal, and the other two at 100m upstream and downstream from the outfall point. If the outfall river is big (mention approximate depth and width), the cross sections may be taken up to the deep channel at the place of the section. Positions of these cross-sections are to be shown on the sketch plan prepared.

(b) If the subproject TBM is far from the start point of survey, its RL should first be carried to a site TBM near the survey start point and survey of first cross-sections started with the back reading from this site TBM. For subsequent cross-sections, RL from the start point of previous cross-section will be carried to the start point of the new cross-section.

7. Survey of Khal Cross-Sections

(a) First cross-section of the khal shall be at Ch 0+00 (start point defined above) and other cross-sections shall be surveyed at every 100m proceeding upwards. All cross-sections will be serially numbered. At start of survey of every cross-section, Chainage of khal and the cross-section number should be written in the Level Book.

(b) Cross-sections are to be surveyed up to the point beyond which khal does not exist or the khal joins another khal or the point up to which re-excavation has been instructed. If the khal joins another khal at upstream end which is not planned for re-excavation, that khal should also be surveyed with three cross-sections like the outfall khal.

(c) At each cross-section of khal, staff readings are to be taken at 1 (one) m intervals starting from 5 m away from the left bank (according to flow direction) of khal and ending at 5 m away from the right bank. However, additional staff readings are to be taken, as necessary, to define bed width of khal or significant change in elevations. If there is embankment along the khal and is close to the khal bank, the khal cross-section shall include the embankment up to 5m beyond its outside toe.

(d) Additional cross-sections, other than the 100m internal sections, will have to be surveyed, as necessary, to depict special conditions of the khal – wide and/or narrow sections, reach of deeper channel, etc.

(e) During survey of khal, locations and important dimensions (chainage, opening size, bed and top levels) of existing structures on the khal (bridge/culvert/regulator/sluice) are to be recorded in Level Book. For box culverts, sluices, regulators, water retention structures, top level of base slab (invert level), top levels of upstream and downstream floors must be recorded carefully using hand sketch. Existing condition of the structures (good or bad) are also to be recorded.

(f) When a branch khal is found, its Chainage of outfall, location (left or right side), bed level of the khal being surveyed and bed level of the branch khal as well as depth and top width of the branch khal should be noted in the Level Book in a small hand sketch with local name of the branch khal.

C. Survey of Embankments

8. Embankments are usually developed along existing alignments of village roads to reduce land loss. As existing alignments are used, setting out of embankment center line on ground is not required. Before staring the survey work, RL of the subproject TBM should first be carried to a site TBM near the start point of embankment survey and then cross-section survey will proceed as outlined below.

(a) Start point of survey with Ch 0+000m of embankment should be identified on ground and the position should be defined by physical condition (crossing point of roads, end point of a bridge/culvert, etc) or by distance from two fixed reference objects. The location and referencing of the start point should be recorded in the Level Book with a hand sketch. Survey of the first cross-section be started with back reading from the site TBM.

(b) Cross sections of embankments are be surveyed at 100 m intervals and at each cross-section staff readings are to be taken at every 1.5m distance starting from centre line of the existing road or embankment first towards countryside (c/s) and then towards riverside (r/s) up to 10 m away from toe of the existing road/embankment. Additional staff readings may be needed at places to depict real situation.

(c) Additional cross-sections other than those at 100m intervals are to be surveyed, as required, to depict particular existing conditions like breaches, too weak sections, sections at homestead places, etc.

D. Plane Table Survey of Structure Sites

(a) Detail physical conditions and features of the area surrounding a hydraulic structure should be clearly known at the time of its designing so that subsequent undesirable situations can be avoided. For this, Plane Table (PT) survey with spot GL at 5m grid points over an area around the center point of the structure should be done when the structure site has been finally decided. If any structure site is changed, the PT survey should again be at the new site. PT survey with GL at grid points will be submitted in A3 size drawing.

(b) The PT survey area shall be as below for the usual range of structures used in SSWRD subprojects:

Regulator/sluice/WRS up to 2-vent sizes: 50m x 50m around structure center

Regulator/sluice/WRS above 2-vent sizes: 100m x 100m around structure center

=x=

Exhibit G4-E:
Field Survey Forms for Agricultural Data and Information

Subproject Name:

Upazila:

District: Date of Survey: Name and Designation of Surveyor(s):

Table G4-E.1: Crop Patterns

No.	Name of Crop Cultivated in Three Seasons			Percent of Total Cultivated Area in Each Land Type			
	Kharif 1	Kharif 2	Rabi/Boro	High Land	Medium High Land	Medium Low Land	Low Land
Total				100	100	100	100

Crop Pattern: The name of crops grown on the same piece of land one after another covering three crops seasons in a year. For example, B. aus-LT Aman-Wheat crop pattern indicates land is cultivated in kharif I, kharif II and rabi seasons.

Crop seasons: Kharif I: March/April to June; Kharif II: July-October; Rabi: November to March

Land type: Highland (F0): The cultivated land where flooding depth is 0 to 30 cm; Medium highland (F1): The cultivated land where flooding depth is 30 to 90 cm; Medium lowland (F2): The cultivated land where flooding depth is 90 to 180 cm; Lowland (F3): The cultivated land where flooding depth is more than 180 cm

Percent of Total Cultivated Area in Each Land Type: For example, B. Aus-LT Aman-Wheat crop pattern occupies 60% of the total highland, 50% of the total medium highland, 20% of the medium lowland and 5% of the lowland in the proposed subproject area. Accordingly, other crop patterns occupy remaining 40% of the highland, 50% of the medium highland, 80% of the medium lowland and 95% of the lowland.

Table G4-E.2: Crop Cultivation Practices and Input Use

Subproject Name:…………………………………………… Date: ……………………….

Name of Crop	Operation Time (Week/Month)			Irrigated Area (percent of cropped area)					Fertilizer Use (kg/hectare)					Pesticide (kg/ha)	Labor Use (person-day / ha)	Draught Animal Use (pair/ha)
	Sowing	Trans-plantation	Harvest	LLP	STW	DTW	HTW	Traditional	Urea	TSP	MP	Organic	Other			

Operation Time (Week/Month): For example, 3w 4m would mean 3rd week of April
Irrigated area: For example, 20% of the total HYV boro area is irrigated by LLP, 30% by STW and 50% by DTW.
LLP: low lift pump; STW: shallow tubewell; DTW: deep tubewell; HTW: hand tubewell; Traditional: don, sewti
Fertilizer use: TSP: triple super phosphate; MP: murate of potash; organic: compost; green manure; Other: zinc sulphate, gypsum, borax or DAP.
Labor use: labor employed for crop production from sowing to storing.
Person day: eight hours.
Draught Animal: pairs of bullock used for plough, laddering, weeding, threshing, carrying.

Table G4-E.3: Crop Damage (percent of total area under the crop)

Subproject Name:…………………………………………………… Date: ……………………

Name of Crop	Damage free				Damaged by pre-monsoon flooding				Damaged by monsoon flooding			
	High Land	Medium High Land	Medium Low L	Low Land	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land

Table G4-E.3 (contd): Crop Damage (percent of total area under the crop)

Subproject Name:…………………………………………………… Date: ……………………

Name of Crop	Poor drainage				Drought				Pest infestation			
	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land

Table G4-E.4: Crop Yield (ton/hectare)

Subproject Name:…………………………………………………… Date: …………………….

Name of Crop	Damage free cropped area				Pre-monsoon flood damaged cropped area				Monsoon flood damaged cropped area			
	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land

Table G4-E.4 (contd): Crop Yield (ton/hectare)

Subproject Name:…………………………………………………… Date: ……………………

Name of Crop	Poor drainage cropped area				Drought damaged cropped area				Pest infested cropped area			
	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land	High Land	Medium High Land	Medium Low Land	Low Land

Table G4-E.5: Farmers' Needs

Subproject Name:…………………………………………………… Date: ……………………

Name of Crop	Flood Reduction (✓mark)	Flood Protection (✓mark)	Flood control (✓mark)	Crop Protection from Submergence (✓mark)	Drainage Improvement (✓mark)	Increase in Soil Moisture (✓mark)	Irrigation Water Supply (✓mark)	Other (mention)

Table G4-E.6: Farmers' Views on Impact of Proposed Subproject

Subproject Name:…………………………………………………… Date: …………………

Name of Crop	Protect crop form flooding (✓ mark)	Improve drainage (V mark)	Protect crop from drought (✓mark)	Land can be cultivated (✓mark)	Increase in cultivated area (%)	Increase in yield level (%)	No impact, because	Subproject will create problem, because	Other (specify)

Exhibit G4-F:
FISHERIES FIELD SURVEY AND DATA COLLECTION

Subproject Name:

Upazila:

District:

Date of Survey:

Name and Designation of Surveyor(s):

PART-I: SUMMARY

A. Fisheries Resource Base and Production

A-1. Estimation on the basis of secondary data

Type of Water Body*	Area (ha)	Yield (kg/ha)	Production (ton)
F2 + F3			
Perennial Water Body			

* Water Bodies inundated by monsoon flood and likely to be affected by project intervention (Part-IIA)
F2 +F3 = Seasonal Water body with at least 0.9 m of water depth standing for at least 4 months
Perennial Water Body = Lowland and permanent water body like Khal, Beel, Baor, Haor, River segment etc. holding water through the year.

A-2. Estimation on the basis of the field survey

Type of Water Body	Area (ha)	Yield (kg/ha)	Production (ton)
a. Seasonal Flood land**			
b. Beel, Baor, Haor			
c. Khal, River segment			
Total			

** Seasonal Flood Land = Seasonally flooded area of the flood plain with 0.5 m water standing at least for 4 months.

A-3. Particulars of public water bodies

Sl. No.	Type of Water Body	Name of the water body	Area (ha)	Lessee	Lease Value (Taka)	Lease Period From -To (year)

B. Fisheries Community

B-1: Fishers and Fish Farmers (operating within the sub-project area)

Category		Number of Household		Average Annual HH Income	Other Profession	No. of persons involved (# F)	Annual catch per person (Kg)
		Total	Female Farmer HH				
Genuine* Fisher	Ethnic(Hindu)						
	Neo-Fisher						
Subsistence Fisher							
Genuine Fish Farmer							
Subsistence Fish Farmer							

* **Genuine Fisher/ Fish Farmer**: Fulltime fisher/fish farmer spending most of his time in fishing/fish farming and earning livelihood mostly from fishing / fish farming.
Ethnic Fisher:Traditional Hindu fisherman or woman
Neo-Fisher: Fulltime fisher, mostly Muslims, who have adopted the profession in recent years
Subsistence Fisher/ Fish Farmer: Part time Fisher/Fish Farmer

C. Fisheries

C-1 Fish Species

i. Culture Species: (1) .... (2) .... (3) ....
(Name the species cultivated in the sub-project area, if any)

ii. Wild Species (Enclose the list as per proforma below)

Sl. No.	Local Name (with alternative local names)	English Name	Occurrence: 1 =Very Common (50%) 2 =Common (25%) 3 =Rare (10%) 4 =Very rare (5%)

PART II: Particulars of Water Bodies

Type of Water Body a. Seasonal Floodland b. Beel, Baor, Haor c. Khal, River Segment d. Pond, Dighi, Ditch, Borrow Pit								
1. Name, if any								
2. Location (village)								
3. Recorded area (ha)								
4. Total Water Area (ha)								
a. Rainy Season (June-Sept)								
b. Dry Season (Jan-April)								
5. Depth (m)								
a. Rainy Season (June-Sept)								
b. Dry Season (Jan- April)								
6. Fisheries Production (ton/year)								
a. Fish								
b. Prawn (G-Galda,B-Bagda)								
c. Crab								
7. Lease Status								
a. Lessee								
b. Lease Period								
c. Lease value								
8. Seasonality I-Seasonal P-perennial								
9. Tidal Influence (Y/N)								
10. Flooding Source Khal-1, River-2, Other-3								
11. Mode of Fishing Single, Group, CBF								

12. Fishing period								
a. Seasonal (month)								
b. Round the year								
13. Fisheries Type a.Capture Fisheries, b. Culture-based Fisheries c. Culture								
14. Stocking Information								
a. Species stocked*								
b. Number per decimal								
c. Size (cm)								
15. Water Control Structure R-Regulator, S-Sluice, WRS								
16. Fish Passage Control Structure a. Fish- Screen b-Other								
17. Culture Status a-Cultivated b-Cultivable c-Derelict								
18. Type & Mode of Culture a-Monoculture b-Polyculture c-Traditional d-Managed e- Fish and Poultry f- Nursery g-Grow out								
19. Flooding Status a-Flood free b-Flood prone								
20. Mode and Method of Fishing a-Partial b-Total c-Netting d -Dewatering e-Self-fishing f-Contract fishing								
21. Source of Fingerlings a-Natural b-Hatchery raised c-Self collected of raised d-purchased e-Local f-Out sourced								
22. Ownership i-Public ii-Private iii-Institutional								
23. Effect of Project Intervention (Yes / No)								

Note: *Species 1.................. 2.............. 3............... 4 ....5..........

Exhibit G4-G:
FINANCIAL AND ECONOMIC DATA

Table G4-G.1: Input Use and Yield Levels per Hectare

A. In cropped area without water resource management

Crop		Seeds (kg)/ Seedlings (no.) (per ha)	Organic Manure (kg/ha)	Fertilizers				Pesticides (kg/ha)	Irrigation (Tk/ha)	Machine hire* (Tk/ha)	Labour (pd/ha)	Yield (unhusked)	
				Urea (kg/ha)	TSP (kg/ha)	MP (kg/ha)	Other (kg/ha)					Main Product (kg/ha)	By-Product (kg/ha)
Aus Rice	HYV	42	265	140	125	85	5.5	2.0	4236	4415	120	3500	1540
	Local	80	300	60	50	25	0.0	2.0	4236	2810	41	1900	855
Aman Rice	Local	51	300	70	47	16	3.5	1.0	0	2309	90	2300	851
	HYV	50	600	143	96	75	19.8	1.5	1412	1297	124	3700	969
	Deepwater	80	0	55	45	20	0.0	1.0	1412	894	37	1550	698
Boro Rice	HYV	45	1112	213	183	107	33.5	3.0	8472	3774	189	6400	4589
	Hybrid	31	1600	211	215	107	41.4	3.0	9178	4010	210	6795	4335
	Jute	10	371	120	87	37	0.0	1.0	1412	5074	181	1648	2059
	Wheat	122	2100	112	112	51	13.0	1.0	3295	2780	89	2200	1870
	Maize	44	3000	157	134	75	16.0	1.0	4236	5220	113	4500	5085
Sweet	Potato	700	500	103	65	90	0.0	0.0	0	2750	127	7500	0
Oilseed	Mustard	10	3300	88	86	43	0.0	2.0	1412	4633	66	970	158
Pulse	Lentil	33	800	71	91	47	0.0	2.0	0	5791	70	770	105
	Potato	1140	3700	161	141	60	17.4	3.0	12708	4633	192	11500	0
Vegetable	Summer	0.4	2900	119	135	48	8.0	3.4	14826	2862	202	6300	0
	Winter	0.5	1700	201	177	102	31.5	7.0	10166	6178	195	8800	0
Spice	Onion	11	7000	157	198	118	22.5	5.0	5648	4015	287	5300	0
	Chili	1	1100	265	190	100	17.2	5.0	4236	7722	219	3500	0
	Sugarcane	25000	900	135	116	57	0.0	6.0	2118	7862	144	17700	3540
Water	Melon	2	2800	150	135	75	21.5	3.0	6354		205	9235	0
	Banana	1200	1100	278	335	222	0.0	3.0	4497		205	7400	0
	Tobacco	2800	1100	222	296	200	50.0	2.5	3608	3707	383	2669	14820

* For land preparation.

B. In cropped area with water resource management

Crop		Seeds (kg)/ Seedlings (no.) (per ha)	Organic Manure (kg/ha)	Fertilizers				Pesticides (kg/ha)	Irrigation (Tk/ha)	Machine hire* (Tk/ha)	Labour (pd/ha)	Yield (unhusked)	
				Urea (kg/ha)	TSP (kg/ha)	MP (kg/ha)	Other (kg/ha)					Main Product (kg/ha)	By-Product (kg/ha)
Aus Rice	HYV Aus	47	1950	200	150	74.1	15	3	4236	4817	126.69	4064	1804
	Local	80	300	60	50	25	0.0	2.0	4236	2810	41	1900	855
Aman Rice	L T Aman	56.8	988.4	69.2	54.3	27.2	0.0	4.0	0	5001.8	114.6	2935.5	1097.1
	HYV Aman	52.4	1600.0	120.0	105.0	55.0	8.0	7.0	1412	5001.8	139.4	4463.0	1168.6
	Hybrid Aman	39.5	1600.0	160.6	103.7	51.9	49.4	4.0	1412	5003.8	144.8	4645.5	1284.9
	Deepwater	80	0	55	45	20	0.0	1.0	1412	894	37	1550	698
Boro Rice	HYV Boro	45.5	2400.1	225.0	190.0	65.0	15.0	3.0	8472	5189.1	156.0	6850.0	4910.0
	Hybrid Boro	29.7	2718.8	214.9	205.0	73.0	30.6	3.0	9178	5189.1	171.5	7270.0	4638.0
	Jute	9.0	1700.0	87.2	74.1	37.1	0.0	3.0	1412	5436.2	192.9	2700.3	3375.4
	Wheat	124.0	2500.0	150.0	130.0	40.0	23.0	1.0	3295	4633.1	110.0	3320.0	2822.0
	Maize	40.0	2200.0	110.0	95.0	70.0	11.0	2.0	4236	4818.5	123.0	6310.0	7130.3
Sweet	Potato	700	500	103	65	90	0	0	0	2750	127	7500	0
Oilseed	Mustard	10.0	2255.0	148.0	148.0	74.0	5.0	2.5	1412	4633.1	84.0	1230.0	200.0
Pulse	Lentil	30.0	1598.0	74.0	136.0	62.0	7.0	3.0	0	4633.1	74.0	1170.0	159.5
	Potato	1200.0	4260.0	180.0	145.0	90.0	25.0	3.0	12708	4633.1	211.0	19700.0	0
Vegetable	Summer	0.4	3860.0	160.0	90.0	70.0	22.0	4.4	14826	4633.1	230.0	9690.0	0
	Winter	0.4	2100.0	210.0	165.0	110.0	25.0	8.0	10166	6177.5	209.0	11600.0	
Spice	Onion	9.0	1500.0	170.0	190.0	110.0	17.0	3.0	5648	4633.1	303.0	12500.0	0
	Chili	0.7	1200.0	274.0	173.0	97.0	13.0	6.0	4236	7721.9	234.0	4390.0	
	Sugarcane	30000.0	1035.0	183.0	118.0	71.0	0.0	6.5	2118	6177.5	169.0	52000.0	10400.0
Water	Melon	2	2800	150	135	75	21.5	3.0	6354		205	9235	0
	Banana	1200.0	2780.0	278.0	335.0	222.0	20.0	3.0	4497		205.0	8280.0	0
	Tobacco	2800.0	1100.0	222.0	296.0	200.0	50.0	2.5	3608	3706.5	383.0	2668.7	14820.0

* For land preparation.

Table G4-G.2: Conversion Factors

Item of Cost	Conversion Factor*	Item of Cost	Conversion Factor*	Item of Cost	Conversion Factor*
Capital Cost Components		**Agricultural Inputs**		**Agricultural Outputs**	
Engineering Works		**Labour**	0.84	**Products**	
Earthworks	0.90	**Machine**	0.90	Rice	1.171
Structures	0.90	**Seeds**		Wheat	0.786
Roads-Bank Protection	0.90	Paddy	0.90	Jute	0.90
Forestation/Demolition	0.90	Wheat	0.90	Maize	0.90
Labour		Jute	0.90	Tobacco	0.90
Skilled Labour	0.90	Tobacco	0.90	Potato	0.90
Unskilled Labour	0.83	Sugarcane	0.90	Sweet potato	0.90
Machinery/Equipment/Transport		Pulses 3/	0.90	Vegetables	0.90
Transport vehicles	0.90	Oilseeds 3/	0.90	Spices	0.90
Machinery/Equipment	0.90	Potato	0.90	Lentil	0.88
Materials		Sweet potato	0.90	Sugarcane	0.807
Cement	0.90	Vegetables	0.90	Water Melon	0.90
Steel (Basic metal)	0.90	Spices	0.90	Banana	0.90
Bricks and Others	0.90	Others	0.90	Others	0.90
Engineering and Administration	0.90	**Manure**	0.90		
Physical Contingencies	0.90	**Fertilizers**		By-products	0.90
O&M*	0.71	Urea	0.975		
		TSP	1.288		
		MP	1.726		
		Pesticides	0.84		
		Irrigation	0.79		
		Miscellaneous	0.90		

* Weighted average of miscellaneous items.

Table G4-G.3: Estimates of Conversion Factor for Local Cost Component of Capital Cost Items

Item	Skilled Labour		Unskilled Labour		Materials		Taxes & Duties		F.E.C		Transportation		Total	
	%	CF	%	CF	%	CF	%	CF	%	CF	%	CF	%	CF
Embankment	6.34	0.90	78.16	0.833		0.90	15.5	0		1		0.90	100	70.82
Re-excavation of Drainage Channel	6.34	0.90	78.16	0.833		0.90	15.5	0		1	0	0.90	100	70.82
Protective work	17	0.90	17	0.833	25	0.90	15.5	0	20	1	5.5	0.90	100	76.93
Structure	17	0.90	17	0.833	25	0.90	15.5	0	20	1	5.5	0.90	100	76.93

Table G4-G.4: Derivation of Economic Farmgate Prices for Internationally Traded Commodities

Items	Unit	Conversion Factor	Rice		Wheat		Sugar		Triple Super Phosphate		Muriate of Potash		Urea	
			financial	economic	financial	economic	financial	economic	financial	economic	financial	economic	financial	economic
Projected FOB 2011/2025 Price a/	US$/t		407	407	183	183	361.02	361	305	305	274.594	275	203	203
Quality adjustment			0.75	0.75	0.80	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjusted FOB value	US$/t		305	305	146	146	361	361	305	305	275	275	203	203
Freight and Insurance	US$/t		50	50	50	50	50	50	50	50	50	50	0	0
Import price CIF Chittagong , in US$	US$/t		355	355	196	196	411	411	355	355	325	325	203	203
Exchange rate	Tk/$		80.0	80	80	80	80	80	80	80	80	80	80	80
Import price CIF Bangladesh, in Taka	Tk/t		28418	28418	15693	15693	32882	32882	28418	28418	25968	25968	16279	16279
Port, storage, handling, & transport costs from port to regional market	Tk/t	0.90	1752	1578	1752	1578	1691	1523	1140	1027	1140	1027	903	813
Price at regional market	Tk/t		30170	29996	17445	17270	34573	34404	29558	29445	27108	26994	15376	15466
Transport and handling from rice mill to regional market	Tk/t	0.90	750	675	750	675	750	675	500	450	500	450	500	450
Marketing margin and costs to regional market (5%)	Tk/t	0.90	713	642	713	642	713	642	475	428	475	428	475	428
Price in local market	Tk/t		28708	28679	15982	15953	33110	33087	28583	28567	26133	26116	16351	16344
Price of rice/sugar ex-mill														
Equivalent in Paddy (65%) / sugar cane (8%)	Tk/t		18660	18641			2649	2647						
Milling costs	Tk/t	0.90	300	270		0		0		0		0		0
Transport and handling between farm and local market / rice mill	Tk/t	0.90	250	225	250	225	250	225	250	225	250	225	250	225
Farm gate price (calculated)			18110	18146	15732	15728	2399	2422	28333	28342	25883	25891	16601	16569
Farm gate price (actual)			15500	18146	20000	15728	3000	2422	22000	28342	15000	25891	17000	16569
Conversion factor				1.171		0.786		0.807		1.288		1.726		0.975

Source: a) World Bank Commodity Price forecast (constant US dollars),July 26, 2016, Adjusted MUV Index.

Table G4-G.5: Financial and Economic Prices of Inputs of Agricultural Products

Item	Unit	Financial Price (2016)[a]	Conversion Factor [b]	Economic Price	Economic Price Selection Basis
Labour and Machine					
Labour	Tk/pd	230-300	0.84	193-252	Conversion factor
Machine	Tk/Plough/ha	1300-3700	0.90	1170-3300	Conversion factor
Seeds/Seedling					
HYV Aus Rice	Tk/kg	40.0	0.90	36	Conversion factor
Local Aus Rice	Tk/kg	35.0	0.90	31.5	Conversion factor
L T Aman Rice	Tk/kg	40.0	0.90	36	Conversion factor
HYV Aman Rice	Tk/kg	50.0	0.90	45	Conversion factor
Hybrid Aman Rice	Tk/kg	235	0.90	211.5	Conversion factor
Deepwater Aman Rice	Tk/kg	30.0	0.90	27	Conversion factor
HYV Boro Rice	Tk/kg	50.0	0.90	45	Conversion factor
Hybrid Boro Rice	Tk/kg	235.0	0.90	211.5	Conversion factor
Jute	Tk/kg	185.0	0.90	166.5	Conversion factor
Wheat	Tk/kg	38.0	0.90	34.2	Conversion factor
Maize	Tk/kg	62.0	0.90	55.8	Conversion factor
Sweet Potato	Tk/kg cutting	5.0	0.90	4.5	Conversion factor
Mustard	Tk/kg	65.0	0.90	58.5	Conversion factor
Lentil	Tk/kg	125.0	0.90	112.5	Conversion factor
Potato	Tk/kg	40.0	0.90	36	Conversion factor
Vegetable Summer	Tk/kg	13000.0	0.90	11700	Conversion factor
Vegetable Winter	Tk/kg	16950	0.90	15255	Conversion factor
Onion	Tk/kg	2500	0.90	2250	Conversion factor
Chili	Tk/kg	15850	0.90	14265	Conversion factor
Sugarcane	Tk/kg cutting	2.5	0.90	2.25	Conversion factor
Water Melon	Tk/kg	3000	0.90	2700	Conversion factor
Banana	Tk/seedling	2.5	0.90	2.25	Conversion factor
Tobacco	Tk/seedling	0.04	0.90	0.036	Conversion factor
Fertilizers and Pesticides					0
Urea	Tk/kg	16.5-17.0	0.975	16.1-16.6	Conversion facto
TSP	Tk/kg	21-22	1.288	27-28	Conversion facto
MP	Tk/kg	15	1.726	25.89	Conversion facto
Other	Tk/kg	47.5	0.90	42.75	Conversion factor
Manure	Tk/kg	5	0.90	4.5	Conversion factor
Pesticides	Tk/kg	225	0.84	189	Conversion factor
Irrigation	Tk/ha	1412-14826	0.79	1115-11712	Conversion factor

Notes

[a] Source: Department of Agricultural Marketing, Bangladesh Agricultural Development Corporation and Field Survey.

[b] onversion factors based on Bhabodah Feasibility Study, 2017. Bangladesh Water Development Board.

Table G4-G.6: Financial and Economic Prices of Agricultural Outputs

Item	Unit	Financial Price (2016)[a]	Conversion Factor [b]	Economic Price	Economic Price Selection Basis
Main Products					
HYV Aus Rice	Tk/ton	18400	1.171	21546	Conversion factor
Local Aus Rice	Tk/ton	18100	1.171	21195	Conversion factor
L T Aman Rice	Tk/ton	22000	1.171	25762	Conversion factor
HYV Aman Rice	Tk/ton	18850	1.171	22073	Conversion factor
Hybrid Aman Rice	Tk/ton	18850	1.171	22073	Conversion factor
Deepwater Aman Rice	Tk/ton	19500	1.171	22835	Conversion factor
HYV Boro Rice	Tk/ton	17100	1.171	20024	Conversion factor
Hybrid Boro Rice	Tk/ton	17100	1.171	20024	Conversion factor
Jute	Tk/ton	39400	0.90	35460	Conversion factor
Wheat	Tk/ton	19200	0.786	15091	Conversion factor
Maize	Tk/ton	16500	0.90	14850	Conversion factor
Sweet Potato	Tk/ton	16400	0.90	14760	Conversion factor
Mustard	Tk/ton	45600	0.90	41040	Conversion factor
Lentil	Tk/ton	63750	0.88	56100	Conversion factor
Potato	Tk/ton	14830	0.90	13347	Conversion factor
Vegetable Summer	Tk/ton	23100	0.90	20790	Conversion factor
Vegetable Winter	Tk/ton	19900	0.90	17910	Conversion factor
Onion	Tk/ton	29800	0.90	26820	Conversion factor
Chili	Tk/ton	38420	0.90	34578	Conversion factor
Sugarcane	Tk/ton	8000	0.807	6456	Conversion factor
Water Melon	Tk/ton	21000	0.90	18900	Conversion factor
Banana	Tk/ton	28350	0.90	25515	Conversion factor
Tobacco	Tk/ton	91000	0.90	81900	Conversion factor
By-Products					
Local rice straw	Tk/ton	2000-3000	0.90	1800-2700	Conversion factor
HYV rice straw	Tk/ton	2000	0.90	1800	Conversion factor
Wheat	Tk/ton	1000	0.90	900	Conversion factor
Maize	Tk/ton	500	0.90	450	Conversion factor
Jute sticks	Tk/ton	1000	0.90	900	Conversion factor
Sugarcane	Tk/ton	2200	0.90	1980	Conversion factor
Pulses	Tk/ton	1000	0.90	900	Conversion factor
Oilseeds	Tk/ton	1000	0.90	900	Conversion factor
Tobacco	Tk/ton	3000	0.90	2700	Conversion factor

Notes

[a] Source: Department of Agricultural Marketing and Field Survey.

[b] Conversion factors based on Bhabodah Feasibility Study, 2017. Bangladesh Water Development Board.

Table G4-G.7: Financial and Economic 1-Hectare Crop Budgets

A. In cropped area without water resource management

Sl. No.	Crop	Yield (ton/hectare)	Net Return (Tk/ha)	
			Economic	Financial
1	HYV Aus	3.500	64400	75412
2	Local Aus	1.900	34390	40271
3	Local Aman	2.300	50600	59253
4	HYV Aman	3.700	69745	81671
5	Deepwater Aman	1.550	30225	35393
6	HYV Boro	6.400	109440	128154
7	Hybrid Boro	6.795	116195	136064
8	Jute	1.648	649312	58438
9	Wheat	2.200	42240	33201
10	Maize	4.500	74250	66825
11	Sweet Potato	7.500	123000	110700
12	Mustard	0.970	44232	39809
13	Lentil	0.770	49088	43197
14	Potato	11.500	170545	153491
15	Summer	6.300	145530	130977
16	Winter	8.800	175120	157608
17	Onion	5.300	157940	142146
18	Chili	3.500	134470	121023
19	Sugarcane	17.700	141600	114271
20	Melon	9.235	193935	174542
21	Banana	7.400	209790	188811
22	Tobacco	2.669	242879	218591

B. In cropped area with water resource management

Sl. No.	Crop	Yield (ton/hectare)	Net Return (Tk/ha)	
			Economic	Financial
1	HYV Aus Rice	4.064	74778	87565
2	Local Aus Rice	1.900	34390	40271
3	L T Aman Rice	2.936	64581	75624
4	HYV Aman Rice	4.463	84128	98513
5	Hybrid Aman Rice	4.646	87568	102542
6	Deepwater Aman Rice	1.550	30225	35393
7	HYV Boro Rice	6.850	117135	137165
8	Hybrid Boro Rice	7.270	124317	145575
9	Jute	2.700	106392	95753
10	Wheat	3.320	63744	50103
11	Maize	6.310	104115	93704
12	Sweet Potato	7.500	123000	110700
13	Mustard	1.230	56088	50479
14	Lentil	1.170	74588	65637
15	Potato	19.700	292151	262936
16	Vegetable Summer	9.690	223839	201455
17	Vegetable Winter	11.600	230840	207756
18	Onion	12.500	372500	335250
19	Chili	4.390	168664	151797
20	Sugarcane	52.000	416000	335712
21	Water Melon	9.235	193935	174542
22	Banana	8.280	234738	211264
23	Tobacco	2.669	242852	218567

Table G4-G.8a: Fisheries Budget - Perennial Water Bodies

(Per 1 ha Basis)

Items of Benefits/Costs	Physical Unit	Without Subproject					With Subproject				
		Physical	Financial		Economic		Physical	Financial		Economic	
		Quantity/ha	Price/Unit	Value/ha	Price/Unit	Value/ha	Quantity/ha	Price/Unit	Value/ha	Price/Unit	Value/ha
Revenue											
Main product	kg	220	55	12100	47.85	10527	110	55	6050	47.85	5263.5
Sub-total Revenue				12100		10527			6050		5263.5
Operating Costs (excluding labor)											
Gear	ha	1.00	2200	2200	1914	1914	1.00	1100	1100	957	957.0
Craft	ha	1.00	1100	1100	957	957	1.00	550	550	478.5	478.5
Lease Fee	ha	1.00	1000	1000	0	0	1.00	500	500	0	0
Guarding	ha	1.00	700	700	609	609	1.00	350	350	304.5	304.5
Other Costs	ha	1.00	300	300	261	261	1.00	150	150	130.5	130.5
Sub-total Operating Costs				5300		3741			2650		1870.5
Income (without labor costs)				6800		6786			3400		3393
Labor Costs (hired labor)											
March	person-day	5.5	91.00	500.5	63.7	350.4	4.4	91.00	400.4	63.7	280.3
April	person-day	4.0	91.00	364.0	63.7	254.8	3.2	91.00	291.2	63.7	203.8
May	person-day	1.0	91.00	91.0	63.7	63.7	0.8	91.00	72.8	63.7	51.0
June	person-day	1.5	91.00	136.5	63.7	95.6	1.2	91.00	109.2	63.7	76.4
July	person-day	2.0	91.00	182.0	63.7	127.4	1.6	91.00	145.6	63.7	101.9
August	person-day	2.0	91.00	182.0	63.7	127.4	1.6	91.00	145.6	63.7	101.9
September	person-day	3.0	91.00	273.0	63.7	191.1	2.4	91.00	218.4	63.7	152.9
October	person-day	4.5	91.00	409.5	63.7	286.7	3.6	91.00	327.6	63.7	229.3
November	person-day	6.0	91.00	546.0	63.7	382.2	4.8	91.00	436.8	63.7	305.8
December	person-day	7.0	91.00	637.0	63.7	445.9	5.6	91.00	509.6	63.7	356.7
January	person-day	8.0	91.00	728.0	63.7	509.6	6.4	91.00	582.4	63.7	407.7
February	person-day	5.5	91.00	500.5	63.7	350.4	4.4	91.00	400.4	63.7	280.3
Sub-total Labor costs		50.0		4550		3185	40		3640		2548
Income (with labor costs)				**2250**		**3601**			**-240**		**845**

Table G4-G.8b: Fisheries Budget – Floodplain

(Per ha Basis)

Items of Benefits/Costs	Physical Unit	Without Subproject					With Subproject				
		Physical	Financial		Economic		Physical	Financial		Economic	
		Quantity/ha	Price/Unit	Value/ha	Price/Unit	Value/ha	Quantity/ha	Price/Unit	Value/ha	Price/Unit	Value/ha
Revenue											
Main product	kg	50	55	2750	47.85	2392.5	25	55	1375	47.85	1196.3
Sub-total Revenue				2750		2392.5			1375		1196.3
Operating Costs (excluding labor)											
Gear	ha	1.00	250	250	217.5	217.5	1.00	125	125	108.8	108.8
Craft	ha	1.00	125	125	108.8	108.8	1.00	62.5	62.5	54.4	54.4
Lease Fee	ha	1.00	0	0	0	0	1.00	0	0	0	0
Guarding	ha	1.00	0	0	0	0	1.00	0	0	0	0
Other Costs	ha	1.00	100	100	87	87	1.00	50	50	43.5	43.5
Sub-total Operating Costs				475		413.2			237.5		206.6
Income (without labor costs)				2275		1979.3			1137.5		989.6
Labor Costs (hired labor)											
March	person-day		91.00	0	63.7			91.00	0	63.7	
April	person-day		91.00	0	63.7			91.00	0	63.7	
May	person-day		91.00	0	63.7			91.00	0	63.7	
June	person-day		91.00	0	63.7			91.00	0	63.7	
July	person-day	3		0	63.7	191.1	2		0	63.7	127.4
August	person-day	6		0	63.7	382.2	4		0	63.7	254.8
September	person-day	9		0	63.7	573.3	6		0	63.7	382.2
October	person-day	12		0	63.7	764.4	8		0	63.7	509.6
November	person-day		91.00	0	63.7			91.00	0	63.7	
December	person-day		91.00	0	63.7			91.00	0	63.7	
January	person-day		91.00	0	63.7			91.00	0	63.7	
February	person-day		91.00	0	63.7			91.00	0	63.7	
Sub-total Labor costs		30		0	63.7	1911	20		0		1274
Income (with labor costs)				**2275**		**68**			**1138**		**-284**

Exhibit G4-H:
TABLES FOR SELECTING SIZE AND DIMENSIONS OF HYDRAULIC STRUCTURES

(Reproduced from previous *Standard Design Catalogue (not in use now) for use only in feasibility level study)*

Table 2-1: Standard Opening Sizes of Hydraulic Structures (in mm)

Regulator/Sluice		**WRS**	**Weir**	
RCC Pipe (Diameter)	**RCC Box** (Width x Height)	**(Width x Height)**	**Retention Height**	**Overflow Depth**
600	900 x 900	1200 x 1500	1000	600
900	900 x 1200	1200 x 1800	1200	800
1200	1000 x 1200	1500 x 1500	1500	1000
	1200 x 1200	1500 x 1800	1500	
	1200 x 1500	1500 x 2000		
	1500 x 1500			
	1500 x 1800			

Table 2-2: Standard Hydraulic Dimensions of Non-Tidal Regulators/Sluices

Conduit Size W x H (m)	**Discharge Capacity Q** (m^3/s)	**Glacis Drop** (m)		**Glacis Length** (m)		**Basin Length** (m)		**Basin Width** (m)		**Cutoff Depth** (m)	
		C/S	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**
0.60 Dia.	0.5	0.20	0.30	0.60	0.75	3.60	3.75	1.80	1.80	1.20	1.20
0.90 Dia.	1.2	0.30	0.40	0.75	0.75	4.45	4.75	2.50	2.50	1.50	1.50
1.20 Dia.	2.2	0.30	0.40	0.75	0.75	4.45	4.75	3.20	3.20	1.50	1.50
0.90x0.90	1.5	0.30	0.40	0.75	0.75	4.45	4.75	3.00	3.00	1.50	1.50
0.90x1.20	2.1	0.30	0.40	0.90	1.20	4.75	5.00	3.20	3.20	1.50	1.50
1.00x1.20	2.3	0.30	0.40	0.90	1.20	4.75	5.00	3.30	3.30	1.50	1.50
1.20x1.20	2.7	0.30	0.40	0.90	1.20	4.75	5.00	3.50	3.50	1.50	1.50
1.20x1.50	3.4	0.30	0.50	0.90	1.50	5.10	6.00	3.70	3.70	1.80	1.80
1.50x1.50	4.3	0.30	0.50	0.90	1.50	5.10	6.00	4.00	4.00	1.80	1.80
1.50x1.80	5.2	0.40	0.60	1.00	1.80	6.00	7.20	4.50	4.50	2.10	2.10

Note: Discharge capacities Q in non-tidal structures represent discharges at 0.30m hydraulic head (dh).

Basin length and Cutoff wall depths represent values calculated at 0.60 m hydraulic head.

Table 2-3: Standard Hydraulic Dimensions of Tidal Sluices/Regulators in Zone 1 (Very Low Tide Level, Reference Area Patuakhali)

Conduit Size W x H (m)	**Discharge Capacity Q** (m^3/s)	**Glacis Drop** (m)		**Glacis Length** (m)		**Basin Length/ Type** (m)		**Basin Width** (m)		**Cutoff Depth** (m)	
		C/S	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**
0.90x1.20	2.2	0.40	1.50	1.00	3.00	7.00(1)	7.00(2)	3.50	3.50	1.80	1.80
1.00x1.20	2.5	0.40	1.50	1.00	3.00	7.00(1)	7.00(2)	3.70	3.70	1.80	1.90
1.20x1.20	3.0	0.40	1.50	1.00	3.00	7.00(1)	7.00(2)	4.00	4.00	1.80	2.10
1.20x1.50	3.9	0.50	1.50	1.50	3.50	7.50(1)	8.50(1)	4.50	4.50	2.00	2.10
1.50x1.50	5.0	0.50	1.50	1.50	3.50	7.50(1)	9.00(1)	5.00	5.00	2.10	2.40
1.50x1.80	6.1	0.60	1.20	1.50	3.00	8.50(1)	10.00(1)	5.50	5.50	2.40	2.40

Table 2-4: Standard Hydraulic Dimensions of Tidal Sluices/Regulators in Zone 2 (Low Tide Level; Reference Area Barisal)

Conduit Size W x H (m)	**Discharge Capacity Q** (m^3/s)	**Glacis Drop** (m)		**Glacis Length** (m)		**Basin Length / Type** (m)		**Basin Width** (m)		**Cutoff Depth** (m)	
		C/S	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**	**C/S**	**R/S**
0.60 Dia.	0.6	0.40	0.60	1.00	1.50	3.80(2)	4.00(2)	2.00	2.00	1.50	1.50
0.90 Dia.	1.3	0.40	0.90	1.00	2.00	5.00(2)	5.00(2)	2.70	2.70	1.80	1.80
1.20 Dia.	2.3	0.40	0.90	1.00	2.00	6.50	6.50(2)	3.50	3.50	1.80	1.80
0.90x0.90	1.7	0.40	0.90	1.00	2.00	6.00	6.00(2)	3.00	3.00	1.80	1.80
0.90x1.20	2.2	0.40	0.90	1.00	2.00	7.00	7.00(2)	3.50	3.50	2.00	2.00
1.00x1.20	2.5	0.40	0.90	1.00	2.00	7.00	7.00(2)	3.70	3.70	2.00	2.00
1.20x1.20	3.0	0.40	0.90	1.00	2.00	7.00	7.00(2)	4.00	4.00	2.00	2.00
1.20x1.50	3.9	0.50	0.90	1.50	2.00	7.50	8.00	4.50	4.50	2.10	2.10
1.50x1.50	5.0	0.50	0.90	1.50	2.00	7.50	8.50	5.00	5.00	2.10	2.10
1.50x1.80	6.1	0.60	0.90	1.50	2.00	8.50	9.00	5.50	5.50	2.10	2.10

Notes:

1. Discharge values Q of tidal structures shown in Table 2-3 and Table 2-4 represent approximate average discharge rate during drainage period for tidal conditions prevailing in Patuakhali and Barisal districts. These values can be used during the initial stage of subproject planning as indicative figures only. **During the preparation of final designs the structure discharge capacity should be calculated based on actual ground levels and tide levels applicable to the structure site.**

2. Figures in brackets indicate type of stilling basin; (1) = Indian Standard Stilling Basin Type 1, and (2) = USBR Stilling Basin Type 2.

Table 2-5: Standard Hydraulic Dimensions of Water Retention Structures (Gated) (in meter)

Structure Size	Disch. Capacy (m^3/s) Q	Country Side				Sill Length Sl	River Side				Basin Width bw	Chute Blocks Height h_{Ch}	Baffle Blocks		Dentated End Sill Height h_s
		Cutoff Depth $d_{C/S}$	Apron Length $L_{C/S}$	Glacis Length $Gl_{C/S}$	Glacis Rise Gr		Glacis Drop Gd	Glacis Length $Gl_{R/S}$	Apron Length $L_{R/S}$	Cutoff Depth $d_{R/S}$			Dista n-ce d_b	Height h_b	
1-1.2x1.5	2.90	1.80	5.75	0.75	0.30	1.60	0.60	1.50	7.70	2.10	3.50	0.35	1.20	0.42	0.30
2-1.2x1.5	5.80	1.80	5.75	0.75	0.30	1.60	0.60	1.50	7.70	2.10	5.00	0.35	1.20	0.42	0.30
3-1.2x1.5	8.70	1.80	5.75	0.75	0.30	1.60	0.60	1.50	7.70	2.10	7.00	0.35	1.20	0.42	0.30
1-1.2x1.8	3.60	2.00	5.75	0.75	0.30	1.60	0.60	1.50	9.20	2.50	3.50	0.45	1.35	0.54	0.33
2-1.2x1.8	7.30	2.00	5.75	0.75	0.30	1.60	0.60	1.50	9.20	2.50	5.00	0.45	1.35	0.54	0.33
3-1.2x1.8	10.90	2.00	5.75	0.75	0.30	1.60	0.60	1.50	9.20	2.50	7.00	0.45	1.35	0.54	0.33
1-1.5x1.5	3.60	1.80	5.50	1.25	0.50	1.60	0.80	2.00	8.70	2.40	4.00	0.35	1.20	0.45	0.30
2-1.5x1.5	7.30	1.80	5.50	1.25	0.50	1.60	0.80	2.00	8.70	2.40	6.00	0.35	1.20	0.45	0.30
3-1.5x1.5	10.90	1.80	5.50	1.25	0.50	1.60	0.80	2.00	8.70	2.40	8.00	0.35	1.20	0.45	0.30
4-1.5x1.5	14.50	1.80	5.50	1.25	0.50	1.60	0.80	2.00	8.70	2.40	10.00	0.35	1.20	0.45	0.30
								.							
1-1.5x1.8	4.50	2.00	5.75	1.25	0.50	1.60	0.80	2.00	9.70	2.90	4.00	0.45	1.40	0.56	0.35
2-1.5x1.8	9.10	2.00	5.75	1.25	0.50	1.60	0.80	2.00	9.70	2.90	6.00	0.45	1.40	0.56	0.35
3-1.5x1.8	13.60	2.00	5.75	1.25	0.50	1.60	0.80	2.00	9.70	3.00	8.00	0.45	1.40	0.56	0.35
4-1.5x1.8	18.10	2.00	5.75	1.25	0.50	1.60	0.80	2.00	9.70	3.00	10.00	0.45	1.40	0.56	0.35
1-1.5x2.0	5.10	2.20	6.25	1.25	0.50	1.60	0.80	2.00	10.80	3.00	4.00	0.50	1.50	0.60	0.40
2-1.5x2.0	10.30	2.20	6.25	1.25	0.50	1.60	0.80	2.00	10.80	3.00	6.00	0.50	1.50	0.60	0.40
3-1.5x2.0	15.40	2.20	6.25	1.25	0.50	1.60	0.80	2.00	10.80	3.00	8.00	0.50	1.50	0.60	0.40
4-1.5x2.0	20.40	2.20	6.25	1.25	0.50	1.60	0.80	2.00	10.80	3.00	11.00	0.50	1.50	0.60	0.40

For hydraulic energy dissipation during drainage period, Water Retention Structures are provided on the riverside with an Indian Standard Stilling Basin Type 1. The dimensions of the stilling basin appurtenances are determined from the recommended ratios given below. The width and spacing of the appurtenances may need to be adjusted to fit the floor widths of individual structures.

Table 2-6: Standard Hydraulic Dimensions of Weirs (Un-gated) (in meter)

				Country Side		River Side					
Weir Height	Flow Depth	Unit Discharge ($m^3/s/m$)	Total Head	Cutoff Depth	Min. Apron Length	Apron Drop	Impact Blocks Location	Impact Blocks Height	Basin Length	End Sill Height	Cutoff Depth
P	H_e	q	Y	$d_{C/S}$	$L_{C/S}$	A_d	L_P	h_b	L_B	h_s	$d_{R/S}$
1.00	0.60	1.02	1.40	1.50	5.15	0.40	3.90	0.40	5.50	0.20	1.80
1.00	0.80	1.57	1.40	1.50	5.15	0.40	4.70	0.50	6.50	0.30	2.30
1.20	0.60	1.02	1.60	1.50	5.15	0.40	4.20	0.40	5.80	0.20	1.80
1.20	0.80	1.57	1.60	1.50	5.25	0.40	4.90	0.50	6.80	0.25	2.30
1.50	0.60	1.02	2.00	1.95	5.30	0.50	4.70	0.40	6.60	0.20	1.95
1.50	0.80	1.57	2.00	1.50	5.40	0.50	5.50	0.50	7.60	0.25	2.30
1.50	1.00	2.20	2.00	1.50	5.50	0.50	6.30	0.60	8.60	0.30	2.80
1.80	0.60	1.02	2.40	2.45	5.60	0.60	5.10	0.40	7.20	0.20	2.45
1.80	0.80	1.57	2.40	2.35	5.60	0.60	5.90	0.50	8.30	0.25	2.35
1.80	1.00	2.20	2.40	1.80	5.60	0.60	6.60	0.60	9.20	0.30	2.80

ANNEXES