Initial Environmental Examination

Draft

July 2015

Cambodia: Uplands Irrigation and Water Resources Management Sector Project

Prepared on behalf of the Government of Cambodia for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 1 July 2015)

Currency unit	–	riel (KR)
KR1.00	=	$0.00024
$1.00	=	KR4,099.95

ABBREVIATIONS

ADB	Asian Development Bank
AP	Affected Person
BOQ	Bill of Quantities
DFR	Draft Final Report
EARF	Environmental Assessment and Review Framework
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
FFS	Farmer Field School
FWUCs	Farmers Water User Communes
JICA	Japan International Cooperation Agency
JOROP	Joint Reservoir Operations Plan
ICM	Integrated Crop Management
IEIA	Initial Environmental Impact Assessment
IPM	Integrated Pest Management
IWR	Irrigation Water Requirement
MAFF	Ministry of Agriculture, Forest and Fisheries
MEF	Ministry of Economy and Finance
MOU	Memorandum of Understanding
MOWRAM	Ministry of Water and Meteorology
PDWRAM	Provincial Department of Water Resources and Meteorology
PMU	Project Management Unit
PPTA	Project preparatory technical assistance
RGC	Royal Government of Cambodia
Rice-SDP	Climate Resilient Rice Commercialization Development Program
TNA	Training Needs Assessment
TOR	Terms of Reference
WRMSDP	Water Resources Management Sector Development Program

NOTE

In this report, "$" refers to US dollars.

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I. EXECUTIVE SUMMARY

A. Background

1. This report is prepared and submitted as an Annex of the Final Report for Asian Development Bank (ADB) PPTA TA-8702 CAM, the Project Preparatory Technical Assistance (PPTA) for preparing the Uplands Irrigation and Water Resources Management Sector Project. This PPTA is based on agreement between ADB and the Royal Government of Cambodia (Government) and funding of the PPTA is under a grant from the ADB.

2. The overall goal of the Project is to assist the Government to improve the management and governance of existing irrigation systems, increase agricultural production, and improve the productivity of subproject areas with the aim to increase the incomes of poor farmers. The project will focus on increased efficiency of irrigation systems and improved management of water resources in the uplands areas away from the Tonle Sap.

B. Project Components

3. A long list of candidate subprojects was developed during the course of the PPTA, along with selection criteria for finalizing the preferred ones. These criteria identified the first two subprojects to be funded (called "core" subprojects). These are parts of **the Taing Krasaing Scheme** in Kampong Thum Province and the **Prek Chik Scheme** in Battambang Province.

4. The specifications of the proposed core subprojects in the Uplands Irrigation and Water Resources Management Sector Project, which are subject to this impact environmental assessment, comprise works to improve the headworks and main canal of each. Secondary and tertiary canals, as well as extensions to the main canal (in the case of Taing Krasaing) have been included in the "long list" which are covered by the Project Environmental Assessment and Review Framework.

C. The Initial Environmental Examination Report

5. The objectives of the IEE report are to:

(i) Describe the existing natural and socio-economical resources in and surrounding the project area;
(ii) Identify and assess potential significant impacts based on existing environmental conditions including during project pre-construction, construction, and operation / maintenance stages.
(iii) Identify and recommend mitigation measures to minimise any potential impacts caused by project activities,
(iv) Undertake public consultation to present subproject environmental issues to project stakeholders and local people of the subprojects area and to collect community concerns; and
(v) Develop an Environmental Management Plan (EMP) with cost estimates, and including monitoring plans during construction and operation stages to guide subproject implementation.

6. The IEE was prepared following the ADB Safeguards Policy Statement of 2009, the 2003 ADB Environmental Assessment Guidelines, the ADB Environmental Guidelines for Selected Irrigation and Drainage Development Projects of the ADB and relevant environmental policies and guidelines of the Government.

7. The Project is classified under ADB guidelines/rules as a Category B project. Such projects are judged to have some adverse environmental impacts most is occurring during construction phase, but of lesser degree and/or significance than those for category A projects. An initial environmental examination (IEE) is required to determine whether or not significant environmental impacts warranting an EIA are likely. If an EIA is not needed, the IEE is regarded as the final environmental assessment report.

8. Since the subprojects involve the refurbishment of existing irrigation schemes, they do not require environmental impact assessment under Government sub-decree No 72 ANRK.BK. However, where the command area is substantially expanded by the refurbishment of a scheme to provide more than 5,000 ha of newly irrigated land or land previously without reliable irrigation, the provisions of the sub-decree will apply. In the case of the subprojects which are the subject of this IEE, the increase in reliably irrigated land will be in the order of 7,000 – 13,000 ha. This IEE will therefore be forwarded to the Ministry of Environment (MOE) by MOWRAM for project approval under Government requirements.

9. The two core subprojects which are the subject of this IEE have been chosen using a set of selection criteria. Although these criteria did not include specific environmental impact issues, three of them when applied had the effect of selecting for relatively straightforward schemes without significant environmental impacts. These were:

(i) Subproject should involve only rehabilitation of existing systems or related schemes and should not involve construction of new systems.
(ii) Subproject should be located away from the Tonle Sap.
(iii) Subproject should not cause involuntary resettlement and should require as less land acquisition as possible. Subproject should not be a Category “A” for Involuntary Resettlement and Environment; maximum of Category “B” for Involuntary Resettlement and Environment; and Category “C” for Indigenous Peoples.

D. Assessment Findings

10. During construction, the main issues will be air and water pollution and soil erosion, all of which must be managed by strict control of construction contractors. Additional localised traffic congestion is anticipated and this must be minimised by responsible transport planning. Health and safety of construction workers is also, as always, a primary concern.

11. Post-construction, the main concerns are local increases in the levels of agricultural fertiliser and pesticide residues and their effects on water quality and people. Post-construction mitigation will benefit from capacity building and training under the project to use fertilisers and pesticides efficiently and responsibly.

12. There is also a concern that the irrigation schemes must be sustainable and responsibly managed, to ensure that agreed irrigation flows are maintained and other water users are not disadvantaged. The EMP requires a clear and detailed extraction plan for the dry season to be prepared and submitted before construction.

13. Greenhouse gas emissions from the increased area of paddy as a result of the subprojects total approximately 55,000 tons/annum, which is below the threshold of 100,000 tons/annum and requires no further monitoring under ADB’s Safeguard Policy Statement 2009.

14. Adaptation to predicted future increases in irrigation water demand in the subproject

areas have been covered in the design by the use of conservative estimates of irrigation water requirements (IWRs) for potential cropping patterns. The design IWRs exceed the crop water demands in 2020 and 2050 by an average of 23% and 21% respectively.

15. Additionally, the initial rapid environmental assessment (REA) for the Project identified a medium climate risk. Therefore a Climate Risk and Vulnerability Assessment (CRVA) will be undertaken for the whole project.

E. Mitigation Measures

16. Measures to mitigate the above are provided through prior design of infrastructure and also by the rigorous application of social safeguards in the form of Resettlement Plans (RP) and an Ethnic Minority Development Plan (EMDP).

17. Mitigation of construction-phase impacts relies heavily on responsibility of works contractors to follow specification clauses specifically designed to minimise pollution of air and water and soil erosion. This mitigation will in turn rely on enforcement by the Environmental and Social Management Officer in each provincial project management unit and also by construction supervision consultants.

18. Post-construction mitigation will benefit from capacity building and training under the project to use fertilisers and pesticides efficiently and responsibly.

F. Environmental Management Plan (EMP)

19. The IEE includes an EMP where the identified environmental impacts and mitigation measures are transformed into an action plan for their implementation. The plan includes methods of mitigation, responsibilities, indicators of progress, and frequency and nature of monitoring activities with cost estimates.

20. The EMP is a critical document for each subproject. The provisions of the EMP will be incorporated into tender documents and construction contracts.

II. LEGAL AND ADMINISTRATIVE FRAMEWORK

21. This IEE has been prepared for two core subprojects of the Uplands Irrigation and Water Resources Management Sector Project in the Kingdom of Cambodia. It has been designed to satisfy both ADB and relevant Cambodian environmental guidelines and regulations.

A. ADB Environmental Requirements

22. On the basis of subproject screening in the feasibility stage, using a rapid environmental checklist, all subprojects have been determined to be category B for environmental impact. This category entails environmental impacts that can be mitigated. This consolidated IEE has been prepared under the provisions of the ADB's Safeguard Policy Statement 2009 which requires a number of critical considerations, including: (i) project level grievance redress mechanism, including documentation in the environmental management plan (EMP); (ii) physical cultural resources damage prevention analysis; (iii) climate change mitigation and adaptation; (iv) occupational and community health and safety requirements ,including emergency preparedness and response); (v) economic displacement that is not part of land acquisition; (vii) meaningful consultation and participation; and (viii) an EMP which comprises implementation schedule and (measurable) performance indicators.

23. Relevant ADB Environmental policies and guidelines used in the preparation of this IEE are:

(i) Safeguard Policy Statement. ADB, 2009.
(ii) Operation Manual Bank Policies (BP) on Safeguard Policy Statement. ADB, 2009.
(iii) Environment Policy of the Asian Development Bank, November 2002.
(iv) Environmental Assessment Guidelines, 2003 – Annex 3: Content and Format of Initial Environmental Examination (IEE).
(v) Environmental Guidelines for Selected Agricultural and Natural Resources Development Projects (November 1991).
(vi) Rapid Environmental Checklist. ADB, 2013.

B. Government Environmental Regulations

1. Law on Environmental Protection and Natural Resource Management

24. The Law on Environmental Protection and Natural Resources Management was enacted by the National Assembly and launched by the Preah Reach Kram/NS-RKM-1296/36. It was enacted on December 24th, 1996. This law has the following objectives:

(i) To protect and promote environment quality and public health through prevention, reduction and control of pollution;
(ii) To assess the environmental impacts of all proposed projects prior to the issuance of a decision by the Government;
(iii) To ensure the rational and sustainable conservation, development, management and use of the natural resources of the Kingdom of Cambodia;
(iv) To encourage and provide possibilities for the public to participate in the protection of environment and the management of the natural resources; and
(v) To suppress any acts that cause harm to the environment.

25. Under this law the developers or project owners need to prepare an Initial Environmental

Impact Assessment (IEIA) or a full Environmental Impact Assessment (EIA) report for their proposed or existing development projects.

2. Environmental impact assessment process sub-decree

26. The sub-decree No 72 ANRK.BK in the Law on Environmental Impact Assessment Process dated 11 August 1999 sets out EIA procedures. The main objectives of this sub-decree are:

(i) To determine an Environmental Impact Assessment (EIA) for every private and public project or activity, through review by the MOE, prior to the submission for a decision from the Government.
(ii) To determine the type and size of the proposed project(s) and activities, including existing and ongoing activities in both private and public sector prior to undertaking the process of EIA.
(iii) To encourage public participation in the implementation of the EIA process and take into account their input and suggestions for re-consideration prior to the implementation of any project.

27. The sub-decree includes an annex which provides a schedule of developments which require EIA. An excerpt for relevant industries is at Table 1.

Table 1: Annex of Sub-Decree No 72 ANRK. BK. Date 11, August 1999: List of the Projects Required an IEIA or EIA

Type and activities of the projects	Size / Capacity
AGRICULTURE	
Concession forest	≥ 10,000 Hectares
Logging	≥ 500 Hectares
Land covered by forest	≥ 500 Hectares
Agriculture and agro-industrial land	≥ 10,000 Hectares
Flooded and coastal forests	All sizes
Irrigation systems	≥ 5,000 Hectares
Drainage systems	≥ 5,000 Hectares
Fishing ports	All sizes

28. Since the subprojects involve the refurbishment of existing irrigation schemes, they do not require environmental impact assessment under sub-decree No 72 ANRK.BK. However, where the command area is substantially expanded by the refurbishment of a scheme to provide more than 5,000 ha of newly irrigated land or land previously without reliable irrigation, the provisions of the sub-decree will apply. In the case of the subprojects which are the subject of this IEE, the increase in reliably irrigated land will be in the order of 7,000 – 13,000 ha. This IEE will therefore be forwarded to the MOE by MOWRAM for project approval under the Government's requirements.

C. Evaluation Standards

1. Law on the Management of Pesticides and Fertilizers

29. The Law on the Management of Pesticides and Fertilizers was enacted on 14th January 2012. This law has the following objectives:

(i) To support a policy promoting the effectiveness potentiality of agriculture sector, for the development of social and national economy;
(ii) To ensure the safe and effective control of pesticides and fertilizers, whether in consistent with the international standards;
(iii) To enhance public awareness on the implementation of standard requirements of pesticides and fertilizers for all relevant activities related to these products; and
(iv) To reduce risks caused by the use of pesticides and fertilizers, for beneficiary of farmers and people in the nationwide, by ensuring food security, food safety, public health, and the sustainability of environment.

30. The scope of the law shall apply to the management and the implementation of standard requirements for:
(i) All type of pesticides and fertilizers, raw materials or active ingredients and other compositions of pesticides and fertilizers which are used as inputs in agricultural production.
(ii) All activities of natural persons or legal entities who are traders, formulators, pests control services operators, advertisers, donors, and users of all types of pesticides and fertilizers.

2. Law on Water Resources Management

31. The Law on Water Resources Management was adopted by the National Assembly on 22 May, 2007. This law provides procedures for the management of water resources within Cambodia. The purpose of the law is to foster the effective management of the water resources of the Kingdom of Cambodia to attain socio-economic development and the welfare of communities.

32. The Law shall determine:
(i) the rights and obligations of water users;
(ii) the fundamental principles of water resources management;
(iii) the institutions in charge of its implementation and enforcement; and
(iv) the participation of users and their associations in the sustainable development of water resources.

33. Under this law, MOWRAM may declare any basin, sub-basin or aquifer as Water Law Implementation Area when within that basin, sub-basin, ground water or aquifer there are likely to be conflicts among water users, problems of water pollution or watershed degradation.

3. Water pollution control sub-decree

34. The sub-decree No 27 ANRK.BK on Water Pollution Control is dated on April 6th, 1999. The purpose of this sub-decree is to regulate water pollution control in order to prevent and reduce the water pollution of public water so that the protection of human health and the conservation of bio-diversity can be ensured.

35. This sub-decree applies to all sources of pollution and all activities causing pollution of public water areas. The sub-decree also provides the pollution types, effluent standards, and water quality standards in different areas. Water quality standards are stipulated in this sub-decree for public water (Table 2)

Table 2: Water Quality Standard in public water areas for bio-diversity conservation

No	Parameter	Unit	Standard Value
A. River			
1	pH	mg/l	6.5 – 8.5
2	BOD_5	mg/l	1 – 10
3	Suspended Solid	mg/l	25 – 100
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coli-form	MPN/100ml	< 5000
B. Lakes and Reservoirs			
1	pH	mg/l	6.5 – 8.5
2	COD	mg/l	1 – 8
3	Suspended Solid	mg/l	1 – 15
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 1000
6	Total Nitrogen	mg/l	0.1 – 0.6
7	Total Phosphorus	mg/l	0.005 – 0.05
C. Coastal water			
1	pH	mg/l	7.0 – 8.3
2	COD	mg/l	2 – 8
4	Dissolved Oxygen	mg/l	2 – 7.5
5	Coliform	MPN/100ml	< 1000
5	Oil content	mg/l	0
6	Total Nitrogen	mg/l	0.2 – 1.0
7	Total Phosphorus	mg/l	0.02 – 0.09

l = liter; mg = milligram; ml = millilitre
Source: Annex 4 of Sub-decree on Water Pollution Control, 1999

4. Drinking Water Quality Standards

36. For well water used for domestic purposes, including drinking, the Ministry of Industry Mines and Energy Drinking Water Quality Standards of January, 2004 is the evaluation standard. These are summarized in Table 3.

37.

Table 3: Drinking Water Standards

Parameter	Unit	Standard Value
pH	mg/l	6.5 – 8.5
Turbidity	NTU	5
Arsenic	mg/l	0.05
Iron		0.03
Total Dissolved Solid	mg/l	800
Chlorine	mg/l	0.2-0.5
Copper	mg/l	1
Sulphate	mg/l	250
Nitrite	mg/l	3
Nitrate	mg/l	50
Lead	mg/l	0.01
Mercury	mg/l	0.001
Coliform	CFU/100ml	0

5. Solid waste management sub-decree

38. The sub-decree No 36 ANRK.BK on Solid Waste Management is dated on April 27th,

1999. The purpose of this sub-decree is to regulate solid waste management in order to ensure the protection of human health and the conservation of bio-diversity.

39. This sub-decree applies to all activities related to disposal, storage, collection, transport, recycling, dumping of garbage and hazardous waste.

6. Air pollution control sub-decree

40. The sub-decree N^0 42 ANRK.BK on Air Pollution Control and Noise Disturbance is dated on July 10th, 2000. Its purpose is to protect the quality of environment and public health from air pollutants and noise pollution (Tables 4 and 5). This sub-decree applies to all movable sources and immovable sources of air and noise pollution.

Table 4: Ambient Air Quality Standard

Parameters	Period 1h Average mg/m^3	Period 8h Average mg/m^3	Period 24h Average mg/m^3	Period 1year Average mg/m^3
Carbon monoxide (CO)	40	20	-	-
Nitrogen dioxide (NO_2)	0.3	-	0.1	-
Sulfur dioxide (SO_2)	0.5	-	0.3	0.1
Ozone (O_3)	0.2	-	-	-
Lead (Pb)	-	-	0.005	-
Total Suspended Particulate (TSP)	-	-	0.33	0.1

Source: Annex1 of Sub-Decree on Air Pollution Control and Noise Disturbance, 2000.
Note: This standard applied to evaluation of ambient air quality and to monitoring of air pollution status.

Table 5: Maximum permitted noise level in public and residential area (dB (A))

Location	Period		
	06:00 to 18:00	18:00 to 22:00	22:00 to 06:00
Silence Area - Hospital - Library - School - Nursery	45	40	35
Resident Area - Hotel - Administration place - House	60	50	45
Commercial, Services Areas and mix	70	65	50
Small Industrial factories intermingling in residential areas	75	70	50

Source: Annex 6 of Sub-Decree on Air Pollution Control and Noise Disturbance, 2000
Note: This standard is applied to control of noise level of any source of activity that emitted noise into the public and residential areas.

7. Silt/Sediment Quality

41. For the re-use and disposal of silt from canal cleaning or dredging, there is no Government standard. Standards applying to paddy field environments from China and Japan will therefore be referenced. These will include PRC: *GB4284-84 Control standards for*

pollutants in sludge for agricultural use, PRC: *GB/T23486-2009 Sludge quality for afforestation in gardens or forests,* and Japan's *Environmental Quality Standards (EQS) for soil pollution*, August 1991.

8. National Integrated Pest Management Programme

42. The Integrated Pest Management (IPM) Programme in Cambodia was established in 1993 after conducting national workshop on "Environment and IPM". The overall goal of National IPM programme is to promote food security in Cambodia by enhancing the sustainability of intensified crop production system through the promotion of integrated crop management (ICM) skills at farm level. The objectives of this programme are:

(i) to reduce dependence on agricultural chemical, especially pesticides, in agricultural production and to minimize hazards to the human health, animals and environment;
(ii) to develop the capacity of farmers and agricultural technical officers in conducting training and experiments so that they are able to identify problems occurring in agricultural production and find appropriate solution to deal with the problem by themselves; and
(iii) to educate farmers on agricultural technology by enhancing their knowledge on field ecology and by developing skills among farmers in monitoring and analyzing field situations that enable them to manage crops properly.

43. At the national level the position of the IPM programme was strengthened by a Prakas (Ministerial Declaration) in July '02, recognising the National IPM Programme as coordinating body for all IPM related activities in Cambodia. The Prakas also established a Steering Committee and a Deputy Director to act as the National Coordinator.

D. Environmental, Health, and Safety Guidelines

44. ADB's SPS applies pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines. The Guidelines provide the context of international best practice and contribute to establishing targets for environmental performance. The air and noise standards in the EHS guidelines will be used to complement the Government standards in this document where needed.

45. Occupational and community health and safety, as laid out in the EHS Guidelines, will be a cross-cutting assessment for the subprojects.

III. DESCRIPTION OF THE PROJECT COMPONENTS

A. Overall Project

46. The Project will be implemented in Prey Veng, Kampong Thom and Battambang provinces. The uplands of these provinces have potential for improved land and water productivity through improved irrigation systems and water resource management. The Project area will comprise selected irrigation systems in the three provinces, which have potential for growing vegetables and fruits with paddy being the main crop.

47. The Project will (i) rehabilitate, modernize and climate proof existing irrigation systems and improve their performance and management, (ii) enhance land and water productivity through watershed management and land improvement, and (iii) improve management of water resources through participatory irrigation and water resource management.

48. This will comprise capital works to the main canals and side canals including embankments and headworks as well as refurbishment or replacement of cross regulators, offtakes, sluices and bridges. Works will also encompass the construction of new secondary and tertiary canals and drains with regulators, offtake structures and culverts.

49. A long list of candidate subprojects was developed during the course of the PPTA, along with selection criteria for finalizing the preferred ones. These criteria identified the first two subprojects to be funded (called “core” subprojects). These are parts of the Taing Krasang Scheme in Kampong Thum Province and the Prek Chik Scheme in Battambang Province (Figure 1).

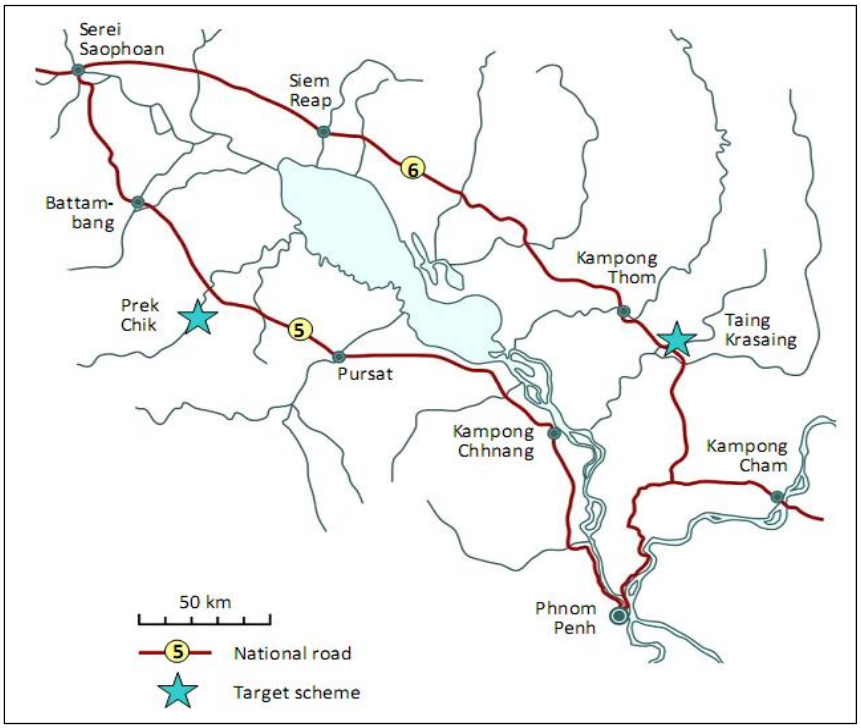


Figure 1: Location of Core Subprojects

B. Provincial Schemes

50. Irrigated agriculture in both Kampong Thom and Battambang provinces is wet season rice-based. If sufficient water is available a second crop of either rice or vegetables and fruits such as pineapple and water melon is sown. During dry season, many lands are observed to be fallow. In general, lands are quite level. In the wet season, the schemes also have drainage problems during the wet season; and water-logged areas are observed in several places.

51. Systems, in general, show poor maintenance of their facilities. Many canals are subject to embankment erosion, especially in the many sandy soils. Recently built systems were observed to be either still incomplete and under delayed construction or abandoned and not usable after just a few seasons. Several lined canal parts/systems were also observed as dry and not connected to a water supply.

52. Farmers employ low-head portable diesel pumps (owned or rented) where the water level in canals or even drains are too low to service lands by gravity. Rice yields are low in general between 0.8 to 1.5 ton/ha, with only a few places reaching 2.5 tons/ha. Post- harvest drying and processing are potentially wasteful with significant losses. Seed- quality is often poor. Most planting is broadcast, and requires both rain and some irrigation to meet the large needs of land soaking and land preparation.

1. Taing Krasaing Scheme

53. The Taing Krasaing (TK) system is located some 25 km south-east of the city of Kampong Thom, close to National Highway No.6, with Phnom Penh a 185 km drive away. The TK system is supplied by a simple reservoir with outlet-control gates (not in use and now cemented) on the Taing Krasaing river. The TK system was constructed during the period 1975-1978, underwent rehabilitation in 2000, and had partial sections improved and modernized in 2005 and 2012. The watershed upstream is estimated at 1,100 km^2. Figure 2 shows the the main canal, supply reservoirs and irrigation communes.

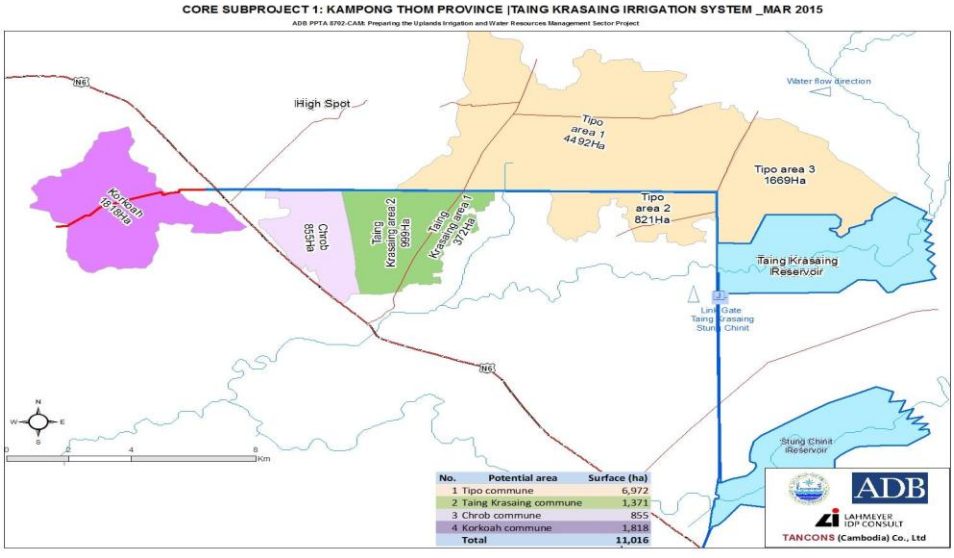


Figure 2: Existing Taing Krasaing Scheme showing Main Canal and Irrigation Communes

2. Prek Chik Scheme

54. Scheme construction of the 28 km long Prek Chik Canal (PKC), linked to the Bassac reservoir via Stug dauntry, was started during 1977. It was unfinished when construction work ceased in late 1978. After 1979, the partly finished canal was largely unused until some small repairs were made by the Battambang PDWRAM in 2003. Major rehabilitation work was done by MOWRAM in 2010 using funding from the Japanese government with the aim of bringing the PKC into effective operation. This construction work was completed at the beginning of 2012. The MOWRAM rehabilitation plan focused on the main canal and its irrigation structures. Figure 3 shows the Prek Chik Gates, Prek Chik Canal and Bassac Reservoir. Figure 4 shows the main canal and irrigation communes of Prek Chik.

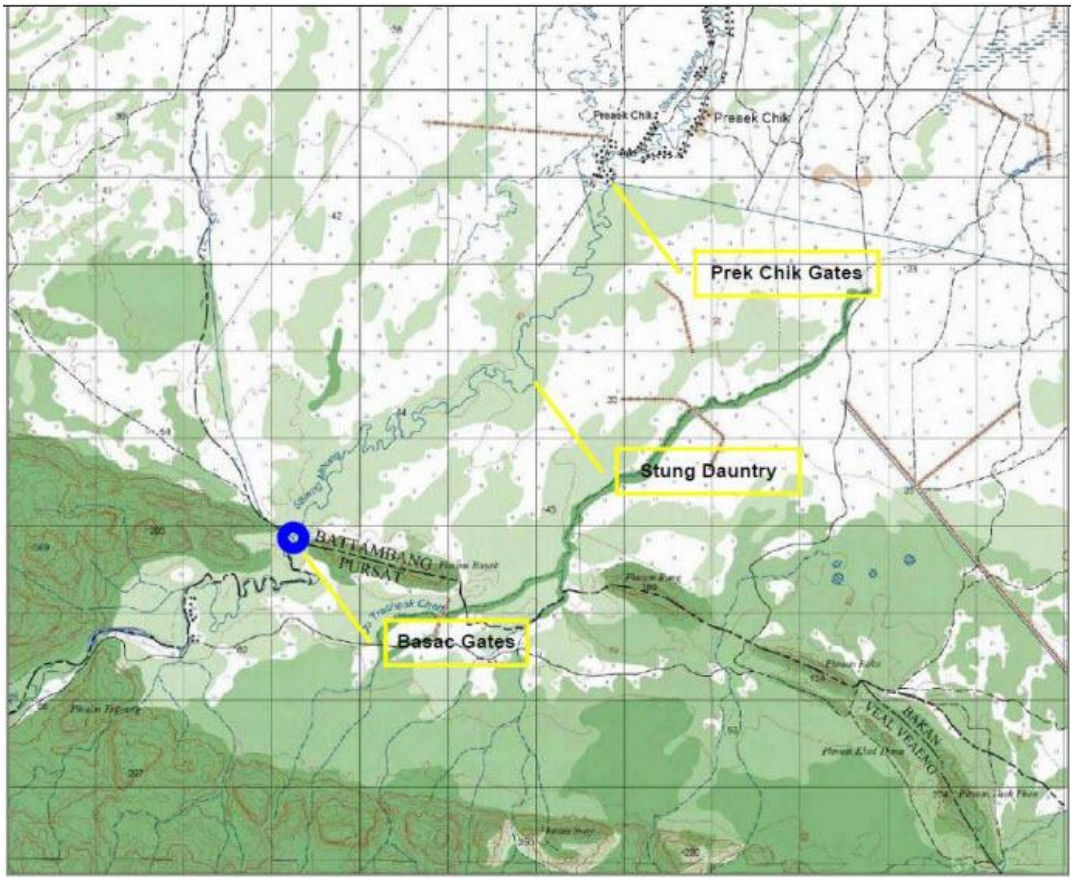


Figure 3: Prek Chik Scheme Setting

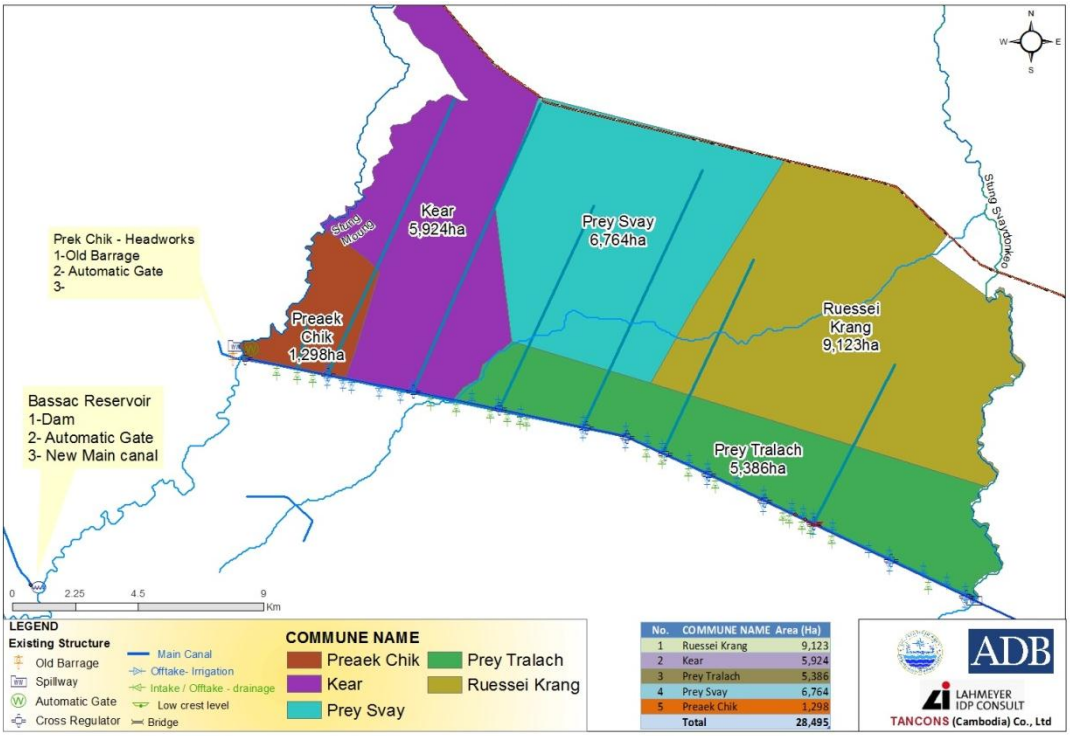


Figure 4: Existing Prek Chik Scheme Showing Main Canal and Irrigation Communes

C. Subproject Components

1. Specifications of Work

55. The specifications of the proposed core subprojects in the Uplands Irrigation and Water Resources Management Sector Project, which are subject to this initial environmental examination, comprise works to improve the main canal of each. Secondary and tertiary canals, as well as extensions to the main canal (in the case of Taing Krasaing) are not included in the core subprojects and are not considered in this IEE, but have been included in the "long list" which are covered by the Project Environmental Assessment and Review Framework. The proposed works are summarized in the following tables and figures.

56. Table 6 and Figure 5 describe the works for Taing Krasaing, and Table 7 describes the works for Prek Chik.

Table 6: Summary of Subproject Structures, Works and Equipment - Taing Krasaing

Description	Unit	Quantity
Headworks		
Improvement of headwork structure	nos	1
Improvement of under sluice gates structures	nos	1
Improvement of spillway	nos	1
Improvement of head regulator	nos	1
Main Canal Section 1 (rd 0+000 to 16+040)		
Main canal earthwork (rd 0+000 to 16+040)	Km	16.04

Description	Unit	Quantity
Improvement of cross regulator	nos	3
Cross regulator (new)	nos	3
Improvement works for offtake type i (single pipe culvert)	nos	2
Improvement works for offtake type III (1 cell box culvert)	nos	4
Offtake type III (1 cell box culvert), new	nos	9
Improvement works for offtake type III(b)	nos	2
Cross drainage structure on main canal	nos	1
Side escape	nos	2
Foot bridge	nos	3
Main Canal Section 2 (rd 16+040 to 18+540)		
Main canal lining (16+040 to 18+540)	Km	2.50
Improvement of cross regulator	nos	1
Cross regulator (new)	nos	1
Offtake type III (1 cell box culvert), new	nos	4
Foot bridge	nos	1

Source: Bills of Quantities prepared by the PPTA team, 6 May, 2015.

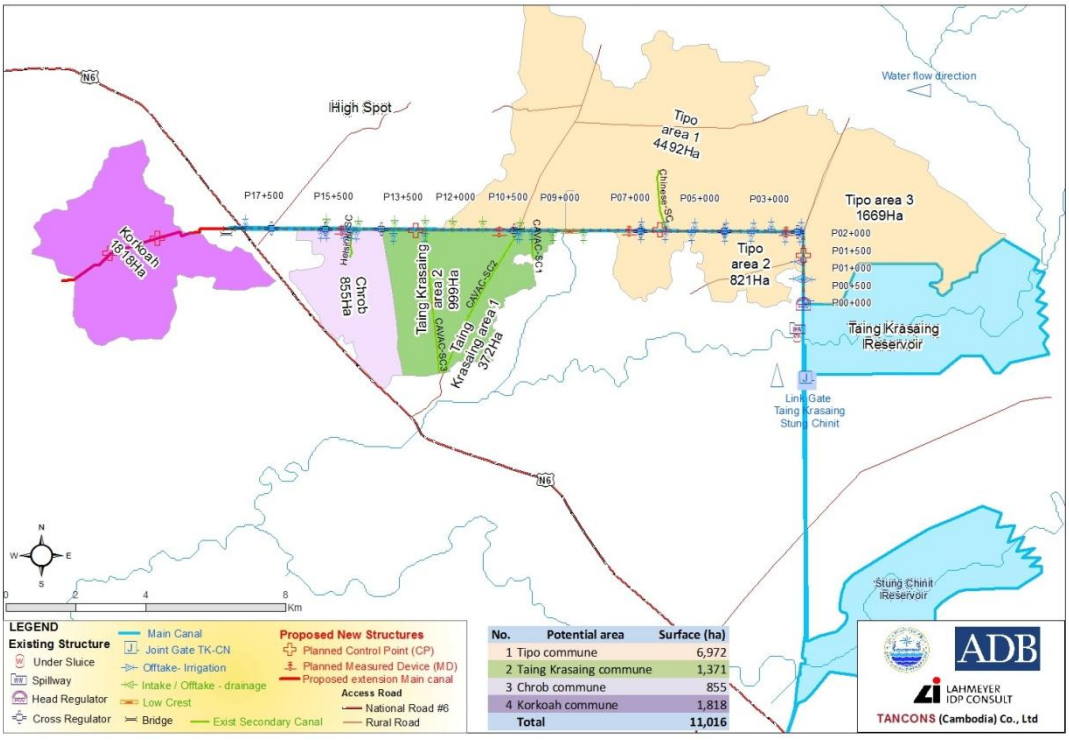


Figure 5: Location of Planned Works along Main Canal - Taing Krasaing

Table 7: Summary of Subproject Structures, Works and Equipment - Prek Chik

Description	Unit	Quantity
Headwork		
Improvement of automatic flappy gates	Nos	1
Improvement of duckbill weir	Nos	1
Improvement of head regulator	Nos	1
Main Canal		
Main canal earthwork	Km	27.6
Improvement of cross regulator	Nos	12
Cross regulator (new)	Nos	10
Improvement works for offtake type i (single pipe culvert)	Nos	27
Improvement works for offtake type III (1 cell box culvert)	Nos	25
Improvement offtake type III(b), (2 cell box culvert)	Nos	4
Offtake type III(b) ,(2 cell box culvert), new	Nos	20
Cross drainage structure on main canal	Nos	3
Foot bridge	Nos	4

Source: Bills of Quantities prepared by the PPTA team, 6 May 2015.

2. Command Areas

57. Work on the two core subprojects will be on the main canals only. No extension of the main canal, secondary or tertiary irrigation canals are included in the core subprojects. However, the rehabilitation of the schemes starting with the refurbishment of the main canals and extending to later secondary and tertiary canals and their control structures will enable a greater area of irrigation to ultimately become available for cropping. The full irrigation command area must therefore be considered in assessing the sustainability of proposed water resource use.

58. Table 8 shows the potential changes in the irrigated area when the subprojects, including the secondary and tertiary canals, are complete.

Table 8: Increases in Irrigated Areas as a Result of the Project

	Taing Krasaing		Prek Chik	
	Before Project	After Project	Before Project	After Project
Irrigated Area (ha)	1,400	9,000	6,000	19,000

D. Project Implementation

59. The Ministry of Water and Meteorology (MOWRAM) will be the executing agency for the Uplands Irrigation and Water Resources Management Sector Project. The Project Management Office (PMO) which is constituted within MOWRAM is based in Phnom Penh, The PMO will set up separate Project Management Units (PMUs) for each subproject to act as implementing agency to manage the implementation of the subproject.

60. Each PMU will comprise a core group of national level technical and administrative staff from MOWRAM, supplemented by staff from the PDWRAM of the province within which the subproject is located. Other members will be drawn from provincial and local agencies on a

case-by-case basis, including staff from the Ministry of Agriculture, Forest and Fisheries (MAAF) and Farmers Water User Communes (FWUCs) from the local communes. For the Taing Krasaing and Prek Chik subprojects the PMUs will be:

Taing Krasaing	**Prek Chik**
Core staff from MOWRAM	Core staff from MOWRAM
Kampong Thum PDWRAM	Battambang PDWRAM
Kampong Thum MAAF officers	Battambang MAAF officers
Local FWUCs	Local FWUCs

IV. DESCRIPTION OF THE ENVIRONMENT

A. The Subproject Provinces

61. The proposed subprojects are in Kampong Thom and Battambang provinces. These provinces are on the upper alluvial plains and piedmont to the east and west of Tonle Sap respectively. In keeping with the selection criteria for project investment, their source waters are from upland flows, rather than the Mekong/Tonle Sap system. The third province within the project, where “long list” subprojects are located is Prey Veng. The three project provinces are shown in Figure 6.

62. The GDP of both provinces are dominated by agriculture. Kampong Thom is Cambodia's second largest province by area and has a population of 710,000. There are a number of significant Angkorian sites in the area, including Prasat Sambor Prei Kuk and Prasat Andet temples. Battambang has a population of 1,036,523, and ranks as the fourth most populous province. In land area, it is the fifth largest province of Cambodia. The province's fertile rice fields have led to a mostly agricultural economy giving rise to Battambang’s reputation as "the Rice Bowl of Cambodia". Battambang province features a range of cultures as well as natural resources. Seventy five percent of its area is jungles and mountains.

Figure 6: Location of Project Provinces

B. Environmental Setting

1. Climate

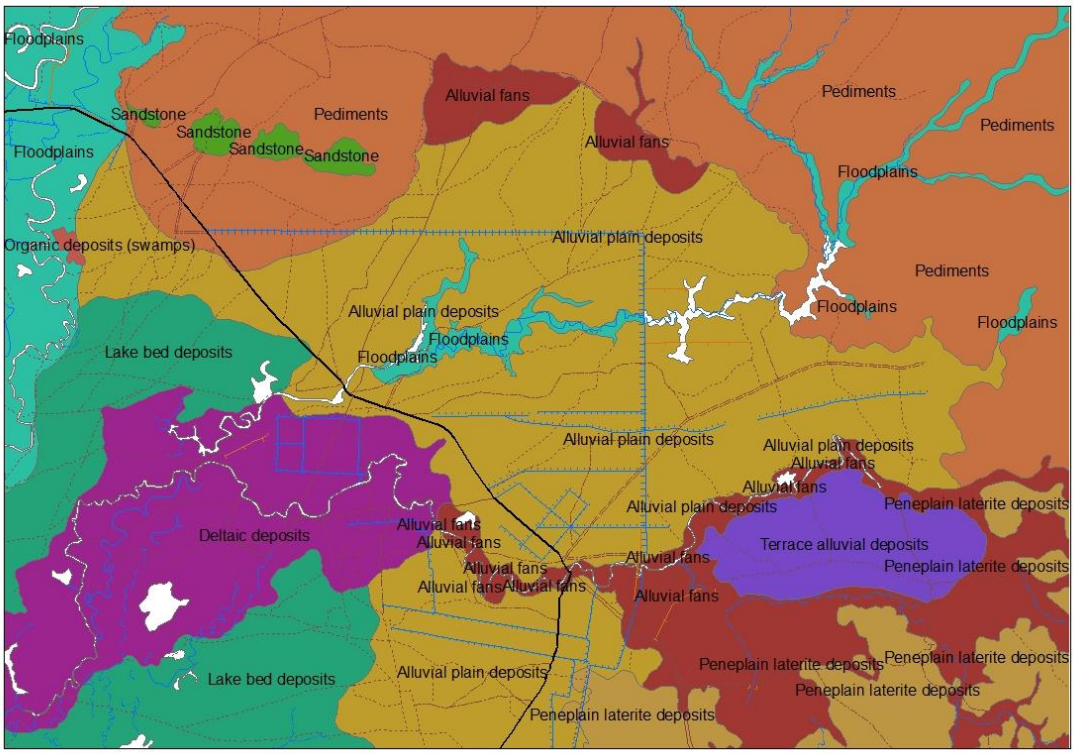
63. The climates of the Battambang and Kampong Thum areas are characterized by distinct rainy and dry seasons. The southwest monsoon starts in May and lasts till October, while from November to April the dry northeast weather patterns predominate.

64. For Battambang, the average annual rainfall ranges from 1,200 mm to 1,300 mm, with peak rainfall occurring in September-October and the lowest rainfall in January. Temperature is lowest in December-January with an average minimum temperature of 26^{o}C and the highest in April with an average maximum of 34^{o}C. The wind direction during the rainy season is prevalent from south-west to north-east and from the south-west during the dry season.

65. For Kampong Thum, the rainfall is slightly higher, with average annual falls of 1300 mm, with peak rainfall occurring in September/October and the lowest rainfall in February. Temperature and wind patterns are similar to those of Battambang.

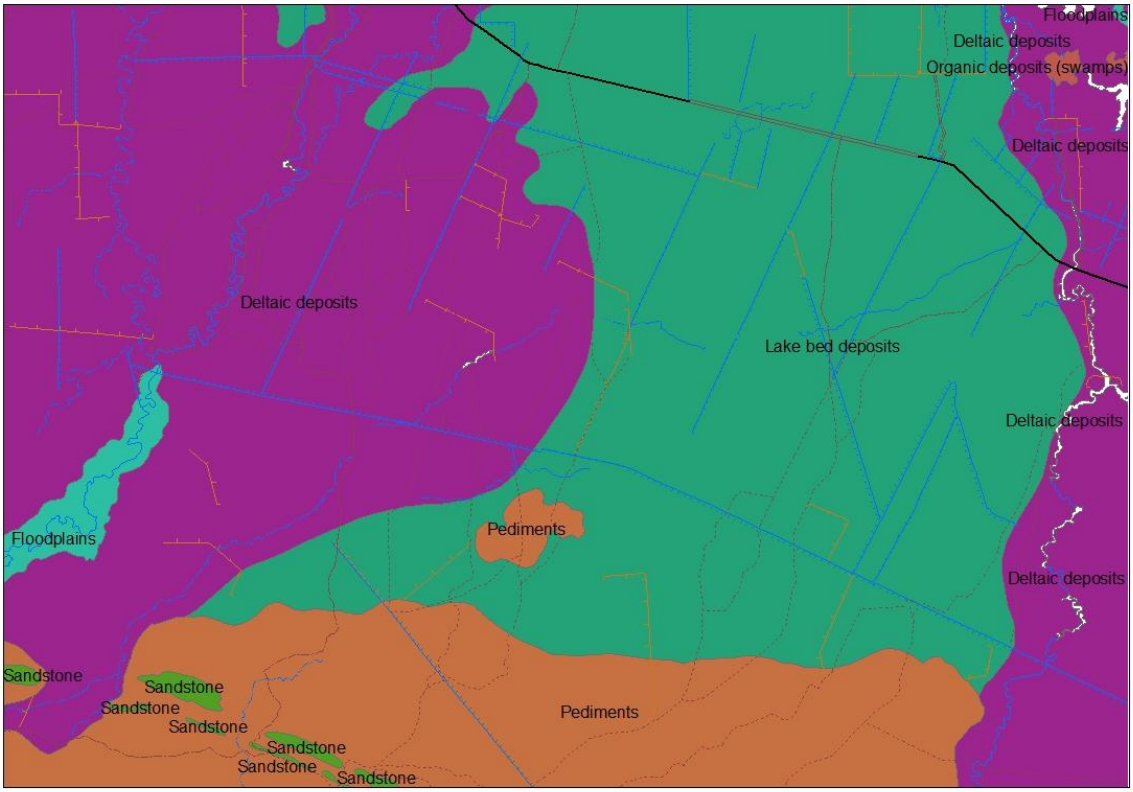
2. Topography and Geology

66. The topography of the subproject areas is flat to gently sloping alluvium, grading to pediment bedrock formations on the upland fringes. Elevation for both areas is between 20 and 30 m ASL (Figures 7 and 8).



Source: JICA GIS Survey of Cambodia, 2005.

Figure 7: Surface Geology of the Taing Krasaing Subproject Area (Kampong Thum Province)



Source: JICA GIS Survey of Cambodia, 2005.

Figure 8: Surface Geology of the Prek Chik Subproject Area (Battambang Province)

3. Hydrology

67. Total inflows to the Taing Krasaing system are shown in Figure 9 below. The yellow (m^3/s) and orange (MCM) highlighted figures in Table 9 show the very low dry season flows.

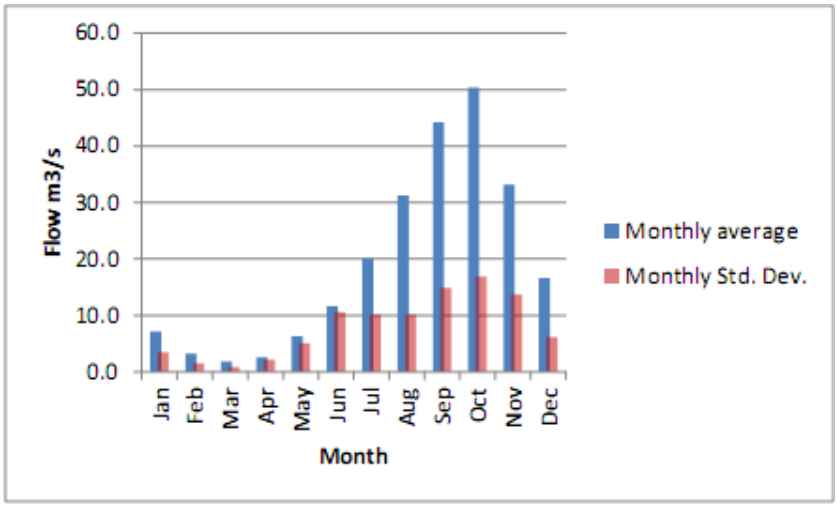


Figure 9: Taing Krasaing Monthly Average Inflows and Standard Deviation

Table 9: Total Taing Krasaing Inflows Monthly Average, Dry, Minimum and Maximum Flows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average. (m3/s)	7.1	3.2	1.8	2.6	6.3	11.6	20.2	31.3	44.2	50.4	33.2	16.6	19.1
Average (MCM)	19.1	7.8	4.9	6.7	16.9	30.2	54.0	83.8	114.6	135.0	86.1	44.6	603.5
Dry year (m3/s)	4.1	2.0	1.2	0.7	0.7	9.0	23.8	36.9	32.3	28.4	15.5	6.9	13.5
Dry year (MCM)	10.9	4.8	3.3	1.8	1.8	23.3	63.8	98.8	83.8	76.1	40.1	18.5	426.9
Max Year (m3/s)	16.2	7.1	3.3	9.2	16.8	53.1	41.5	52.3	76.2	87.9	74.9	32.8	28.4
Max Year (MCM)	43.4	17.2	8.8	23.8	44.9	137.7	111.2	140.0	197.5	235.4	194.2	88.0	900.1
Min Year (m3/s)	0.0	0.0	0.0	0.4	0.5	1.0	1.0	14.5	16.1	26.0	15.5	6.9	10.8
Min Year (MCM)	0.0	0.0	0.0	1.0	1.4	2.5	2.7	38.9	41.6	69.8	40.1	18.5	341.0

Note: The yellow (m^3/s) and orange (MCM) highlighted figures show the very low dry season flows.
Source: PPTA Consultant.

68. Total inflows to the Prek Chik system are shown in Figure 10 below. The yellow (m^3/s) and orange (MCM) highlighted figures in Table 10 show the very low dry season flows.

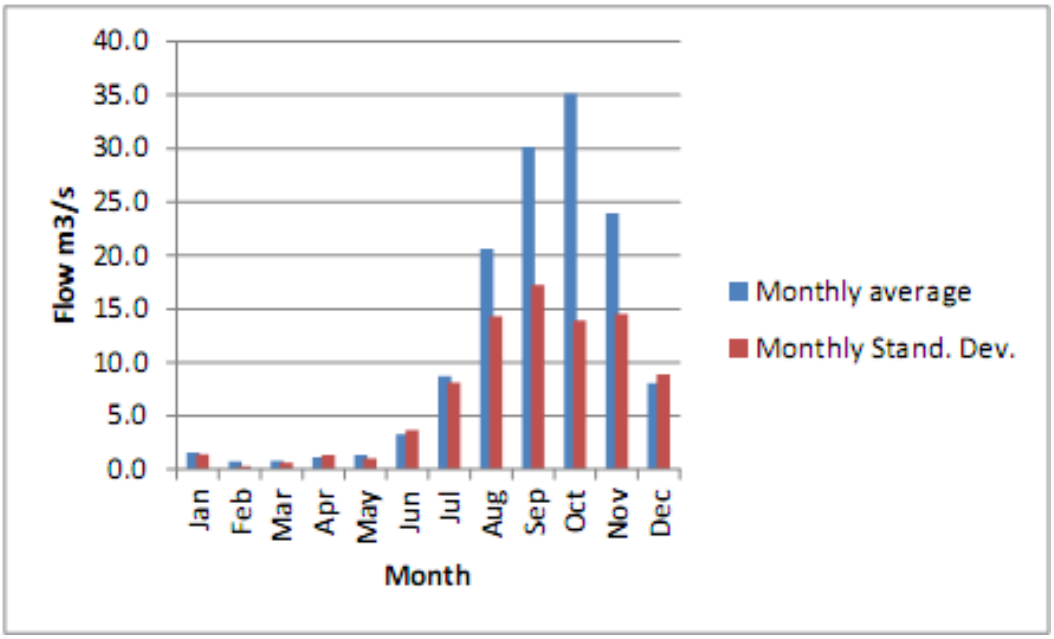


Figure 10: Prek Chik Monthly Average Inflows and Standard Deviation

Table 10: Total Prek Chik Inflows Monthly Average, Dry, Minimum and Maximum Flows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average. (m3/s)	1.5	0.8	0.8	1.1	1.3	3.3	8.7	20.6	30.2	35.2	23.9	8.0	11.3
Average (MCM)	4.1	1.8	2.1	3.0	3.5	8.5	23.4	55.3	78.2	94.2	62.0	21.5	357.7
Dry year (m3/s)	0.6	0.4	0.3	1.0	0.9	2.4	6.2	29.7	29.2	10.7	14.7	2.9	8.3
Dry year (MCM)	1.7	0.9	0.8	2.7	2.3	6.2	16.7	79.5	75.8	28.7	38.2	7.7	261.1
Max Year (m3/s)	6.3	1.4	2.7	6.1	3.6	16.8	36.0	45.5	67.0	64.6	53.9	34.4	19.2
Max Year (MCM)	16.9	3.5	7.2	15.7	9.7	43.6	96.5	121.8	173.6	173.0	139.7	92.2	607.8
Min Year (m3/s)	0.6	0.4	0.3	0.2	0.2	0.5	0.6	1.6	5.3	10.7	5.6	0.9	3.7
Min Year (MCM)	1.7	0.9	0.8	0.5	0.6	1.3	1.7	4.4	13.8	28.7	14.4	2.5	118.2

Note: The yellow (m^3/s) and orange (MCM) highlighted figures show the very low dry season flows.
Source: PPTA Consultant.

4. Water Quality

a. Surface water

69. No water quality data for the subproject areas water bodies currently exist. Baseline water quality of the inflow into the main canals in dry and wet seasons will need to be established in the pre-construction period. This is set as a requirement in the EMP and as a project assurance.

b. Groundwater

70. The vulnerability of groundwater quality in irrigation areas – especially where the water table is high and wells exploit that shallow level. In the Taing Krasaing scheme, farmers' wells are routinely between 2 m and 4 m deep, and therefore share the same water table as the level of water in the main canal. Water in these wells is vulnerable to contamination not only from irrigation water and the agricultural chemicals it might contain but also from domestic and animal waste. In the Prek Chik scheme no wells are used in houses along the main canal. The only wells are found in small house groups between 500 and 1,000 m away from the canal and average 7m in depth. At this depth, the groundwater will be less vulnerable to surface contaminants. Wells were sampled in both schemes using field test kits in the period 24-28 may 2015. The results are listed in Table 11.

Table 11: Groundwater quality results of groundwater at wells in the subproject schemes

Parameter	Unit	Taing Krasaing		Prek Chik		Cambodian Drinking Water standard 2009	US EPA Drinking water
		Well 1	Well 2	Well 1	Well 2		
Depth	m	4	2	7	7		
pH		6.0	6.0	7-7.5	7	5.5-8.5	6.5-8.5
Total alkalinity	mg/l	40	40	240	180	-	-
Hardness	mg/l	50	0	180	180	500	60-200

Parameter	Unit	Taing Krasaing		Prek Chik		Cambodian Drinking Water standard 2009	US EPA Drinking water
		Well 1	Well 2	Well 1	Well 2		
($CaCO_3$)							
NO_2^-	mg/l	2	2	0.2	0.2	1	3
NO_3^-	mg/l	0.2	0.2	20	>20	15	50
Cl	mg/l	<0.25	<0.25	<0.25	<0.25	-	<250
S	mg/l	nd	nd	Nd	nd	-	<250
Fe	mg/l	0.02	0.02	nd	<0.02	5	<0.3
Hg	mg/l	nd	nd	nd	nd	0.5	0.001
Pb	mg/l	nd	nd	nd	nd	0.01	0.01
Cu	mg/l	nd	0.2	nd	nd	1.0	2
Pesticide	mg/l	nd	nd	nd	nd	-	Atrazine: 0.02 Chlorpyrifos: 0.01 Diuron: 0.02
Coliform	>1CFU/100ml	positive	positive	positive	positive	3	positive
Coliform	$>10^3$CFU/ml	negative	negative	negative	negative	3	negative

Note: nd = not detected
Source: *PPTA Team.*

71. The results indicate that the wide use of wells by households in the Taing Krasaing scheme for all domestic water makes them vulnerable to pollution due to their shallow depth. The quality analysis showed coliform counts in excess of drinking water standard, but suitable for animals and washing. Water was slightly acid with low total alkalinity. Iron is present, but not at contamination levels. There are no detectable heavy metals or pesticide residues. Nitrites are elevated, but within standard, and may be a result of fertilizer applications. Salinity is low.

72. The results for the Prek Chik scheme samples are for much deeper wells. However like Taing Krasaing coliform counts are in excess of drinking water standard, but suitable for animals and washing. Water is very alkaline and "hard". There are no detectable heavy metals or pesticide residues. Nitrites and nitrates are elevated, but within standard, and may be a result of excessive fertilizer applications. Salinity is low.

5. Air Quality and Noise

73. No ambient air quality data exists for the subproject areas (nor the provinces). As rural areas, the air quality is sometimes affected by dust from tillage and unpaved road users and smoke from rice stubble burning after harvest and swidden cultivation on the slopes. At most times however, due to the absence of industry and low traffic volumes, the air quality can be expected to be high, with low NO_x and SO_x and minimal CO.

74. Ambient noise levels were sampled in the subproject areas with a noise meter. 10 min averages, maximum and minimum levels were recorded for locations along the main canals. The results are at Table 12 and show typical rural environmental noise levels for minimum measurements. Maximum noise levels are a result of trucks travelling at speed along the roads atop the canal levee banks and have raised the 10 min average levels.

Table 12: Environmental Noise levels in the subproject schemes

Parameter	Unit	TK			PC			42 ANRK.BK Standard	EHS Target
maximum	dB	62	65.5	61.5	72	69.5	63	-	-
minimum	dB	32.6	31	34.5	37	36.5	33	-	-
10 min average	dB	35.5	35	36.5	45.5	41	42.5	60-50 (1 hour average)	55 (1 hour average)

Source: PPTA Team.

6. Land Use and Vegetation

75. Land use in the subproject areas is agricultural, comprising actively farmed paddy fields or abandoned paddy fields. The distribution of land use and vegetative cover of the areas is shown in Figures 9 and 10.

76. In both actively farmed paddy fields and abandoned paddies, a mixture of natural and plantation-escaped trees and shrubs have established along the bunded boundaries of fields, along roadsides and along canal banks. In abandoned paddies there is adventitious growth of shrubs, weeds and grasses.

77. At Taing Krasaing, these comprise:

Natural regrowth (along field, road and canal margins)	Escapes from orchards and plantations
Dipterocarpus tuberculatus	*Borassus flabellifer (sugar palm)*
Diospyros Sp	*Anacardium occidentale (cashew)*
Peltophorum pterocarpum	*Hevea brasiliensis (rubber)*
Azadirachta indica	
Cistus sp	
Zizyphus mauritania	

78. No vegetation species identified on site is included in the IUCN Red List for Cambodia.

79. Vegetation along the banks of the TK main canal is almost exclusively *Peltophorum pterocarpum,* and along the edges of paddy fields *Dipterocarpus tuberculatus* dominates. This is illustrated in Figures 11 and 12 below.

Figure 11: *Dipterocarpus* growing on field bunds, Taing Krasaing

Figure 12: *Peltophorum* growing along canal banks, Taing Krasaing

80. At Prek Chik, which is more intensively cultivated, there is significantly less vegetation on field margins. Recent work on the main canal banks and roadmaking along the levee top has also denuded the main canal of fringing vegetation. What exists among the paddy fields comprises trees and shrubs, predominantly *Streblus asper, Diospyros Sp* and *Azadirachta indica* (Figures 13 and 14).

Source: JICA GIS Survey of Cambodia, 2005, revised by PPTA Team 2015.

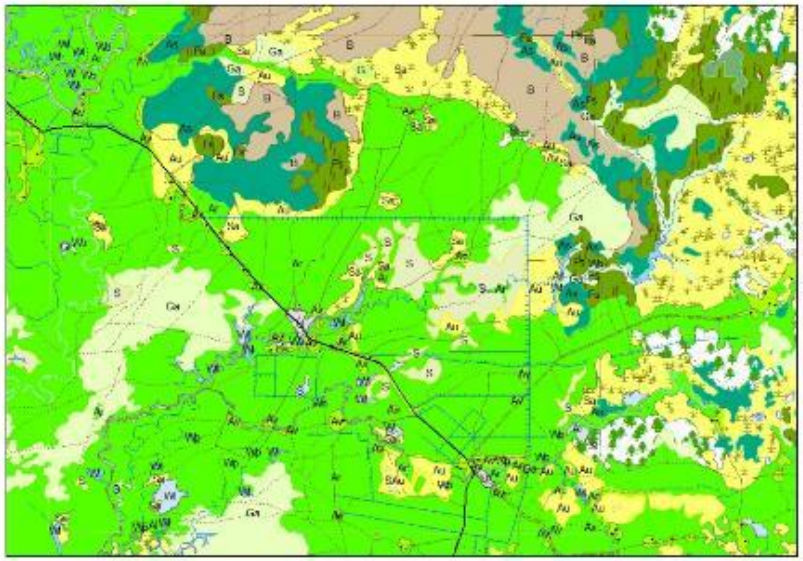


Figure 13: Land Use and Vegetation at the Taing Krasaing Subproject.

Figure 14: Land Use and Vegetation at the Prek Chik Subproject.

Figure 15: *Streblus asper* and *Diospyros* growing on field bunds, Prek Chik

Figure 16: Main canal showing sparse vegetation, Prek Chik

81. No vegetation species identified on site is included in the IUCN Red List for Cambodia.

7. Fisheries

82. Limited household fishing is carried on in the main canals. These are illustrated in Figures 17, 18 and 19. Based on discussions with local farmers and fisher families (often the same group), the common fish found in the project areas, especially within the main canals are listed in Table 13. The Taing Krasaing canal has a slightly larger species list, possibly due to its proximity to Chinit reservoir. In contrast, the Prek Chik scheme is water poor drawing its supply from the Stung Dauntry, which in turn flows only intermittently from the Bassac reservoir more than 13 km upstream. None of the species identified in this opportunistic survey are listed as endangered.

Table 13: Inventory of Fish Caught in the Main Canals

Local Name	Scientific Name	Comments	TK	PC
Trei Ros/ Ptuok	*Channa striata*	Migrates for breeding	X	X
Trei Andeng Tun	*Clarias macrocephalus*	Migrates for breeding	X	X
Trei Chhpin	*Barbodes gonionotus*		X	X
Trei Riel	*Henicorhynchus siamensis*		X	X
Chhlang	*Mystus filamentus*		X	X
Trei Kes	*Micronema bleekeri*		X	-
Trei Kagnchruk	*Botia modesta*		X	-
Trei Kamphleanh	*Trichogaster trichopterus*	Migrates for breeding	X	X
Trei Kamphleav	*Kryptopterus moorei*	Migrates for breeding	X	X
Kanh Chanh Chras	*Pseudambassis notatus*		X	-
Kanh Chos	*Mystus mysticetus*	Migrates for breeding	X	X
Kan Trob	*Pristolepis fasciata*		X	X
Khnong Veng	*Dangila lineata*	Migrates for breeding	X	X
Kranh	*Anabas testudineus*	Migrates for breeding	X	X
Kros phnom	*Poropuntius deauratus*	Migrates for breeding	X	X
Angkat Prak	*Cyclocheilichthys microlepis*		X	X
Slat	*Notopterus notopterus*		X	X

Local Name	Scientific Name	Comments	TK	PC
Ta Aun/ Kramorm	*Ompok bimaculatus*		X	X
Sraka Kdam	*Cyclocheilichthys repasson*	Migrates for breeding	X	X

TK = Taing Krasaing; PC = Prek Chik

Figure 17: *Fishing in main canal*, Prek Chik

Figure 18: Main canal catch, Prek Chik

Figure 19: Main canal catch, Taing Krasaing

83. Migratory fish in the canals will travel upstream, through sluice gates or downstream to secondary and tertiary canals through their life cycle. The subproject works will not change this situation. No impoundment structures or over-topping weirs will be constructed by the subprojects. Only existing watergates will be rehabilitated.

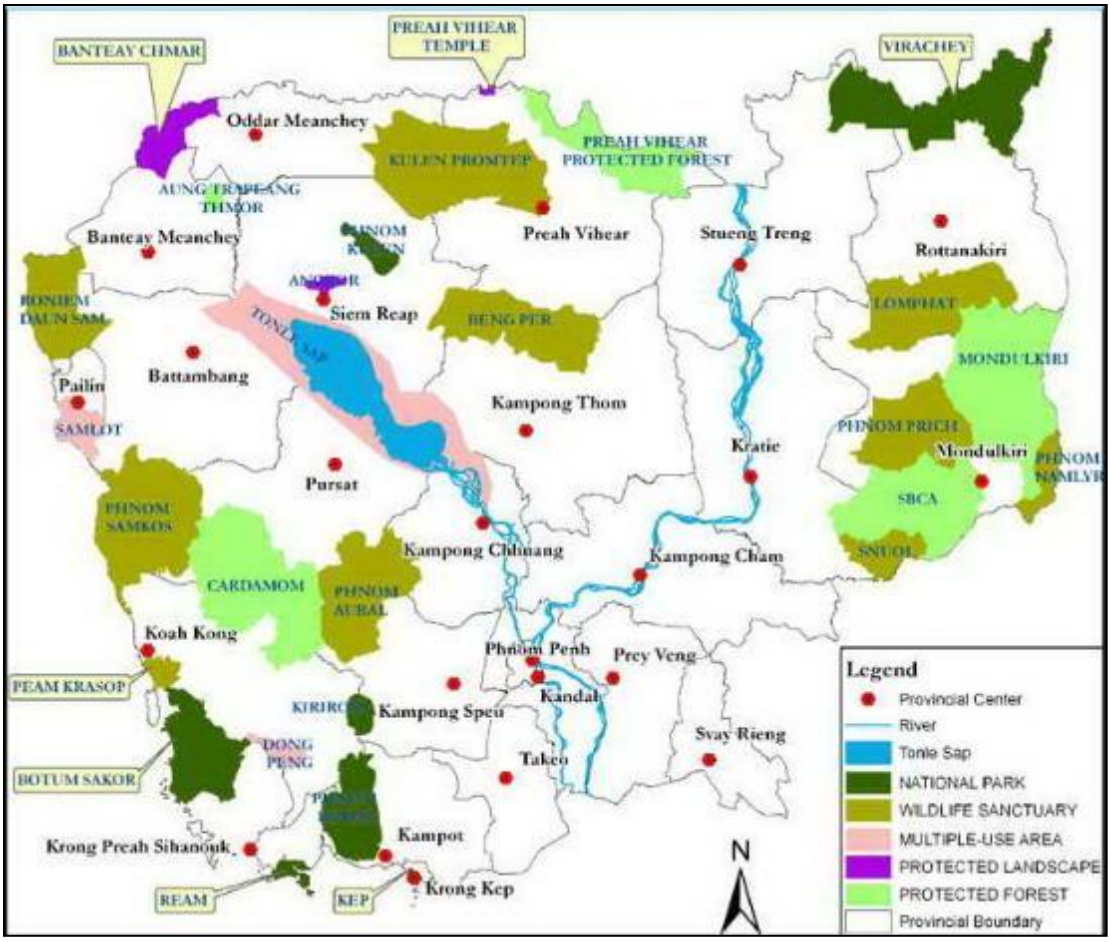
84. No data on fisheries production or fishing effort was available, but observation and discussion indicate that fishing is undertaken as a supplementary activity during dry season when the paddy fields are in fallow. Fish catches are primarily for domestic consumption, with a proportion of the catch being dried and marketed locally.

8. Protected Areas

85. Cambodia has a network of 23 protected areas managed through MOE. These areas cover 2.2 million hectares or 18% of Cambodia's land area and include most of its important habitats. The Forest Administration has also designated protected forests (from cancelled logging concessions) bringing the total area under protection to around 25% which is more than twice the global average. Protected Areas are sites which are protected by Royal Decrees, Laws and Regulations.

86. In 2008 Cambodia introduced the Protected Area Law (No. NS/RKM/0208/007), which defines these areas by their main conservation significance:

(i) national parks
(ii) wildlife sanctuaries
(iii) protected landscapes
(iv) multiple use areas
(v) Ramsar sites
(vi) biosphere reserves
(vii) natural heritage sites and
(viii) marine parks



Source: http://www.mekong-protected-areas.org/cambodia/pa-map.htm

Figure 20: Protected Areas in Cambodia

87. The nearest protected area from this list to both schemes is the Tonle Sap Biosphere Reserve. Kampong Thum also has the Beng Per Wildlife sanctuary and Battambang, the Phnom Samkos wildlife sanctuary. These are shown in Figure 20. None are closer than 50 km to the subprojects

C. Agricultural Practice

88. Most farmers still use traditional rice varieties with low yield potential. Where modern varieties have been introduced farmers use self-saved seed or seed from neighbours. There is very little renewal by regularly purchasing commercial seed. The water requirement for pre-saturation of rice land is usually 150 to 200 mm but if the pre-saturation period is long (24 to 48 days) or where the soil is sandy and free draining this figure can rise considerably. In addition, a water layer (usually at 100 mm) is established at this time. 50% of the total irrigation water requirement can be used for pre-saturation and establishing a water layer.

89. The cropping calendars in Figures 21 and 22 were developed by the PPTA team in discussion with subproject area farmers. It illustrates the usual cultivation and growing cycle of one 90 day wet season rice crop per year which relies upon rainfed water. Less usually, where there is sufficient water to grow a wet season and a dry season crop, short season rice varieties are planted. Depending on water availability and on farmers' preferences and a market being

identified, a vegetable are other cash crop may be planted.

90. Most rice is now harvested mechanically using combine harvesters and Prek Chik farmers estimate that harvesting losses can be 20% or more, mainly due to uneven ripening.

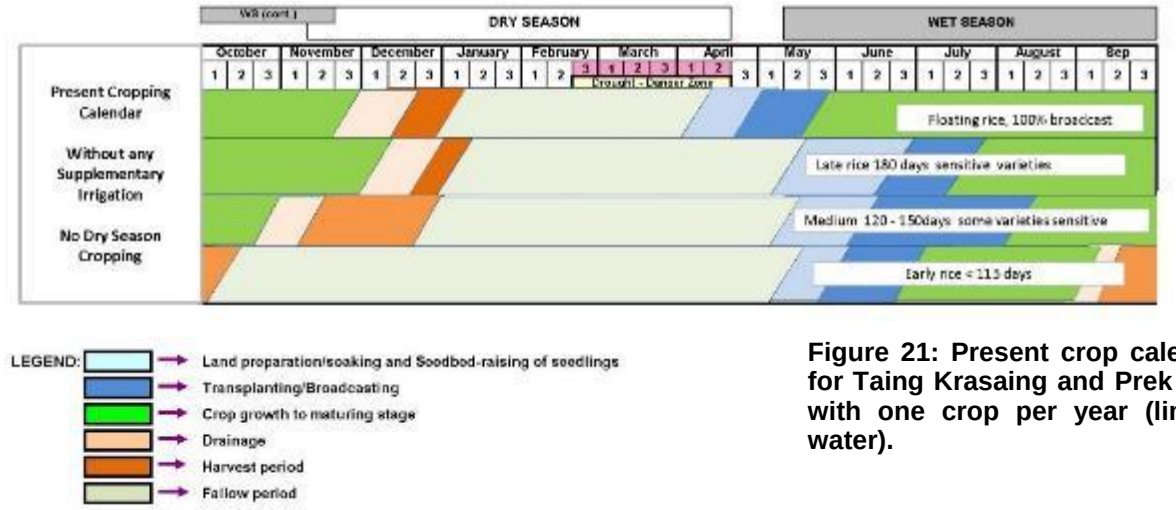


Figure 21: Present crop calendar for Taing Krasaing and Prek Chik with one crop per year (limited water).

Figure 22: Present crop calendar for Prek Chik with two crops per year (more available water)

91. No quantitative data is available on the use of agricultural chemicals in the subproject areas. Discussions with farmers and local sales agents suggest that farmers are reasonably inflexible in their usage levels, following either past practice or packet instructions. Pesticides available in the subproject areas include highly toxic products such as diuron and atrazine (Figure 23), which require careful handling and separation from aquatic ecosystems.

Figure 23: Agricultural Chemicals for Sale in the Prek Chik Subproject Area

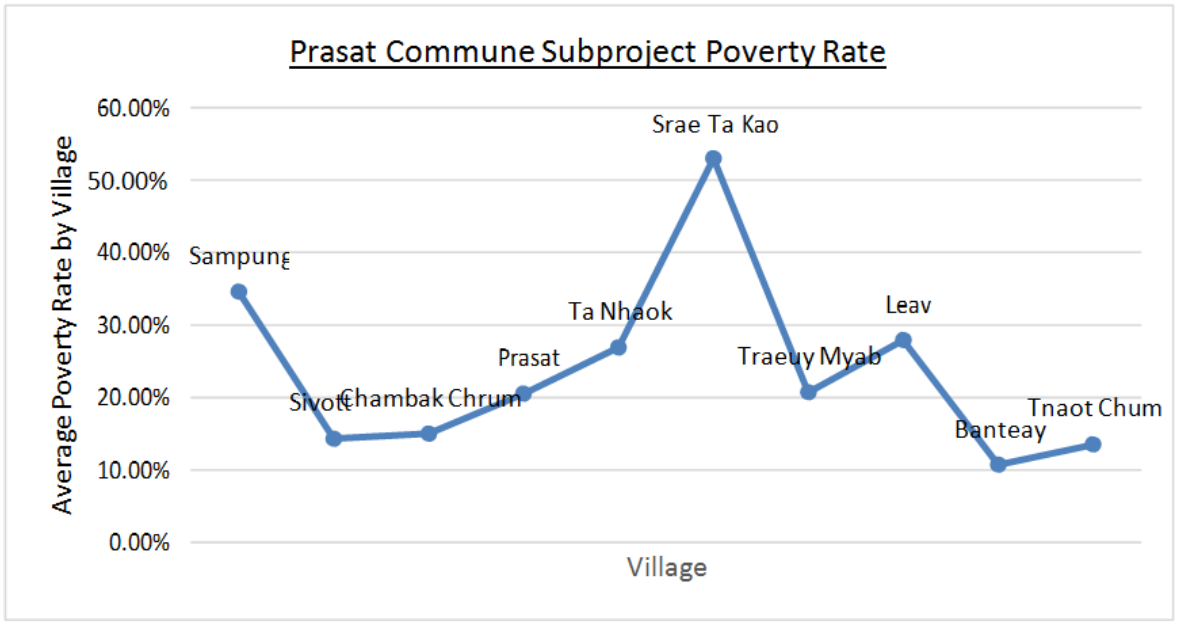
D. Human and economic development

92. Indicative parameters for the human and economic development of the area are summarised in Table 14.

Table 14: Social Indicators of Subprojects

Key Indicator	Taing Krasaing	Prek Chik Phase I (10,000 Ha.)
Area Net (ha)	9,868	10,000
No. of Farmers	19,178	6,663
Population	39,357	48,890
No. of Villages	19	11
No. of Districts	1 (Santuk)	2 (Moung Ruissey and Rukh Kiri)
No. of Households	7,939	10,367
No. of Women Households	1,056 (13%)	1,486 (14%)
Poverty Rate	24.3 – 39%	23.5 – 34.5

93. Although the poverty rates in both areas have been steadily decreasing, the improvement is not consistent across the communes. This is illustrated in Figure 24 below for communes in Taing Krasaing. It is possible that uneven cropping opportunities as a result of the non-functioning irrigation schemes contribute to this inequality.



Source: PPTA Team

Figure 24: Uneven Poverty Rates in Communes within the TK Scheme

E. Floods and Extreme Weather Events

94. Flooding is a regular phenomenon in Cambodia, with rainfalls commonly exceeding 500mm per month in the rainy season. However, recent flooding in the Mekong region has been very damaging and the Mekong River Commission records show an increasingly shorter

return period for major floods. The following flood statistics for the subproject provinces in Table 15 illustrate the levels of damage.

Table 15: Impact of flooding (18 October 2013)

Province		Kampong Thom	Battambang
Affected Districts		7	14
Affected communes		61	102
Affected Families		1,7463	74,160
Affected people		80,330	341,136
Evacuated families		1,114	4,504
evacuated people		5,124	20,718
Houses affects		17,463	62,451
Victims	Deaths	24	17
	Injured	3	4
Flood Affected	Schools	121	77
	Pagodas	41	14
	Health centers and hospitals	4	9

Source: Humanitarian Response Forum (HRF), Situation Report No.4, 23 October 2013

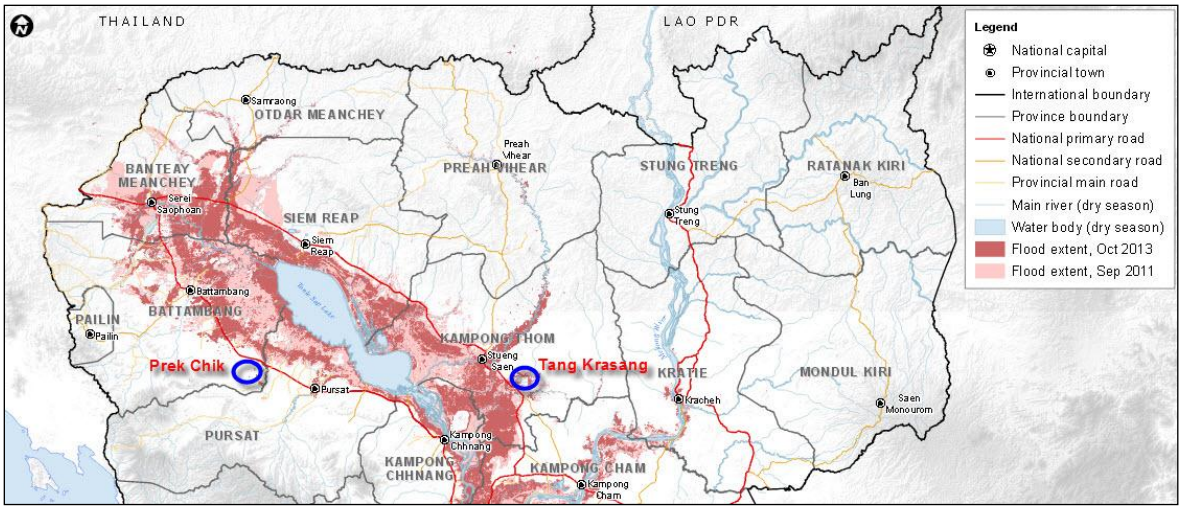
95. Table 16 below compares data collected by NCDM in 2013 and 2011, at the peak of the floods in each year, by Province. Changes in the number of affected or evacuated families in 2013 compared to 2011, are highlighted.

Table 16: Affected and Evacuated Families in 2013 and 2011 (Kg. Thom and Battamabang)

Province	2013	2011	Comparison (affected families) 2013 and 2011	2013	2011	Comparison (Evacuated families), 2013 and 2011
	affected families	affected families		Evacuated families	Evacuated families	
Battambang	74,160	13,921	+60,239	4,504	1,194	+3,310
Kg. Thom	17,463	54,414	-36,951	1,114	2,448	-1,334

Source: Humanitarian Response Forum (HRF), Final Report No.07, December 2013

96. Data on flooding in the subproject areas is unavailable, but national mapping of the 2011 and 2013 floods (Figure 25) shows that the Taing Krasaing subproject wall fully affected by these floods, but that the Prek Chik area was only marginally affected.



Source: World Food Programme Cambodia 2013

Figure 25: 2011 and 2013 Floods

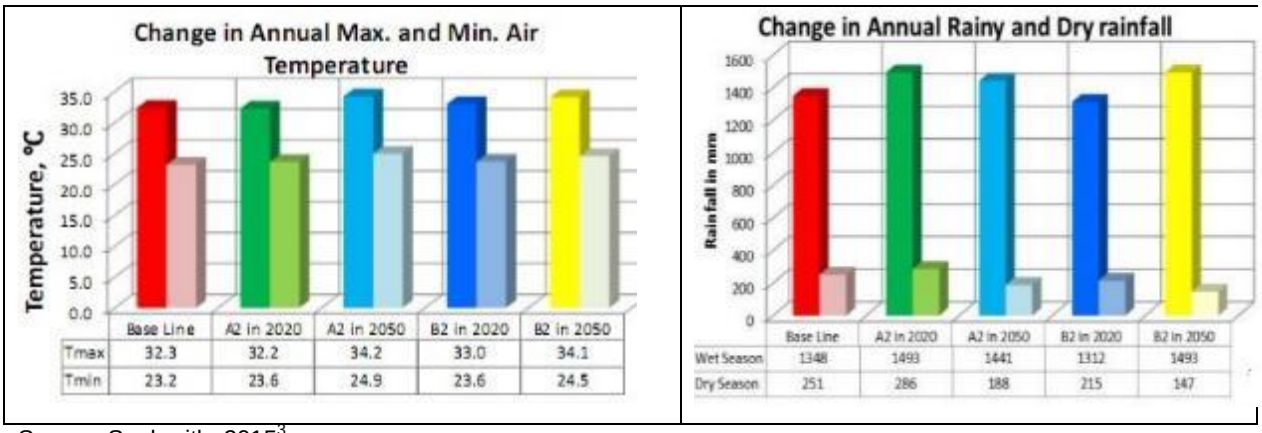
F. Climate Change Scenarios

97. The result of modelling studies in the Initial National Communication (INC) and the Second National Communication (SNC) of the Cambodian National Climate Change Committee indicates that Cambodia's mean surface temperature has increased by 0.8°C since 1960, and that it will continue to increase at a rate of between 0.013°C and 0.036°C per year up to 2099. The rate of temperature increase will be higher in low altitude areas such as the subproject sites which are between 10 and 20 m ASL.

98. Under elevated CO_2 with low rate of emission scenarios (SRESB1)[1], it is likely that wet season rainfall will continue to increase in future, and then might decrease again after 2050. But under high emission scenarios (SRESA2), the direction of change will reverse[2]. The magnitude of these changes are illustrated in the following graphs (Figure 26), and their implications for subproject design are discussed in the following chapter.

[1] IPCC's Special Report on Emission Scenarios (SRES) has four scenarios A1, A2, B1 and B2 describing differing emission rates and geopolitical settings. In summary; A is economics driven rather than environmental; B is more environmentally drive. 1 is countries operating in concert; 2 is countries pursuing their own aims.

[2] National Climate Change Committee 2013, Cambodia Climate Change Strategic Plan 2014-2023



Source: Sopharith, 2015[3]

Figure 26: Graphs showing future scenarios for the critical agricultural parameters of temperature and rainfall.

Scenarios are A2 (a more divided world) and B2 (a world more divided, but more ecologically friendly)

99. An increase in the temperature is likely to affect agricultural productivity. According to the International Rice Research Institute, rice grain yields decline by 10% for each 1°C increase in minimum (night) temperatures during the growing period in the dry season.[4]

[3] Tes, S. 2015. *Assessment of Water Resources for Improved Water Governance under Climate Change: Stung Chinit River Catchment.* Presentation to Third Steering Committee Meeting Climate Change and Water Governance in Cambodia 20 January 2015 , Cambodiana Hotel, Phnom Penh

[4] irri.org/news/hot-topics/rice-and-climate-change

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Positive Impact and Environmental Benefits

100. The two core subprojects which are the subject of this IEE have been chosen using a set of selection criteria. Although these criteria did not include specific environmental impact issues, three of them when applied had the effect of selecting for relatively straightforward schemes without significant environmental impacts. These were:

(i) Subproject should involve only rehabilitation of existing systems or related schemes and should not involve construction of new systems.
(ii) Subproject should be located away from the Tonle Sap.
(iii) Subproject should not cause involuntary resettlement and should require as less land acquisition as possible. Subproject should not be a Category "A" for Involuntary Resettlement and Environment; maximum of Category "B" for Involuntary Resettlement and Environment; and Category "C" for Indigenous Peoples.

101. The result of the project irrigation and drainage facilities will be (i) an increase in certainty and control of existing irrigation areas; (ii) expansion of reliable irrigation into new areas; and (iii) winning of longer cropping periods on areas previously unavailable for parts of the year due to flooding.

102. Table 17 below compares–based on above assessment details–the two core subprojects with respect to the key agro-inputs and practices for the situation today (the "without" project case) and what can be expected in the "with" project case.

Table 17: Project Benefits through Agro-Inputs and Practices of the Two Subprojects

				Tang Krasang		Preuk Chik	
	Characteristic	Season	Unit	Without TODAY	WITH - Future	Without TODAY	WITH Future
1	Cropping Intensity	WS	%	80	100	100	100
	Cropping Intensity	DS	%	Zero	30	5	40
2	Yield	WS	t/ha	1.5	2.7	1.8	3.2
		DS		Zero	3.2	2.2	3.9
3	Fertilizer	WS	% using	< 30	90	80	100
		DS		Zero	100	100	100
4	Land Preparation	Mechanized	%	80	90	80	95
5	Planting	WS	Transplant	20	20	15	25
			Broadcast	80	80	85	75
		DS	Transplant	Zero			20
			Broadcast	Zero		100	80
6	Seed type		Self-saved	100%		Self-saved	90%
7	Vegetable	See Note					
8	Other Crops	See Note					
9	Harvest	WS	Combine	70	85	90	90
		DS			85	90	90

Notes: WS= Wet Season; DS = Dry Season
Vegetables and other crops to be included pending additional information collection

103. In terms of areas sown, the project will increase potential rice growing areas by 40%, and cropping area by 60%. The beneficiaries of these changes will be local farmers, with flow-on effects to local commercial enterprises. Since rural populations are the poorest sectors of the Cambodian population, poverty alleviation effects will be direct and sustainable.

B. Environmental Measures during Pre-Construction Phase

104. A number of environmental management measures will be implemented in the pre-construction phase to ensure that appropriate plans and documentation to determine environmental performance of construction and operation of subprojects are in place. These include:

(i) Updating EMP: Mitigation measures defined in this EMP will be updated and incorporated into the detailed design to minimize adverse environmental impacts. This will be the responsibility of the PMUs.

(ii) Final designs of embankments, siting of control structures and canal alignments will be completed after taking into account the provisions of the EMP.

(iii) Contract documents: Preparation of the environment section in the Terms of Reference for bidders for construction contracts and environmental contract clauses for contractors, namely the special conditions (referencing the EMP and monitoring plan). This will be the responsibility of the PMUs with the support of the PMICs.

(iv) Establishment of the Grievance Redress Mechanism during the subproject design.

(v) Environmental Protection Training: Environmental specialists and/or officials from local MOE offices will be invited to provide training on implementation and supervision of environmental mitigation measures to contractors. This will be the responsibility of the PMUs.

C. Impacts and Mitigation Measures during the Construction Phase

1. Contractor Performance and Site Management

105. To ensure that construction contractors are able to implement the mitigation measures, the PMUs will put in place the following arrangements: (i) environmental specifications will be included in the bidding documents to contractors; (ii) an appropriate environment section describing standards and responsibilities will be included in the terms of reference for bidders; (iii) material haulage routes, and waste disposal arrangements will be defined in the construction tender documents as appropriate; and (iv) clauses referencing the EMP mitigation provisions and monitoring plans will be written into the construction contracts. Following the award of construction contracts, the successful head contractor will prepare a Site Environmental Management and Supervision Manual, including an emergency preparedness and response plan for construction emergencies and site environmental health and safety plan, for approval by the PMUs.

106. During construction, the Environmental Management Officers of each PMU will be active in site supervision, management and appraisal, so as to identify problems and solve them in a timely fashion. Environmental training, especially related to environmental management by the contractor, is included in the EMP.

2. Construction

107. The following impacts and mitigation measures refer to construction impacts which are common to both subprojects. Both will require earthworks, soil stabilization, dust and noise control as well as management of the impacts from machinery operation, transport and haulage of building materials and the domestic needs of the workforce. Occupational and community health and safety issues are discussed separately in Section H below.

108. **Spoil disposal:** The Bill of Quantities for the Taing Krasaing subproject indicates that excavation volumes from embankments and canal will be generally balanced with embankment fill volumes. The subproject only plans for the disposal of 1,600 m^3 of unsuitable spoil (too sandy for compaction). This spoil will be made available to nearby communities for use as building pads and bunds. No spoil disposal is planned for the Prek Chik subproject.

109. **Dredge Spoil:** The Taing Krasaing canal improvement works will involve dredging of the canal to establish contoured shape and design slopes. The dredge spoil volume is estimated at 74,000 m^3. The sediment quality of the dredge spoil will need to be tested and assessed against an appropriate standard before reuse in the structure of embankments (see Monitoring Plan in EMP). The sediment testing results will confirm safe reuse of the material. No material will be dredged from the main canal of the Prek Chik subproject.

110. **Erosion of disturbed surfaces:** The areas most vulnerable to erosion are temporary construction sites, and other places where surface soil will be disturbed. This will total 20,000 m^2 of "clearing and grubbing work" along the length of the main canal at Prek Chik and 3,500 m^2 at Taing Krasaing. The most effective erosion control will be interception drainage to protect disturbed surfaces from surface flows. Construction plans will include erosion control prescriptions for construction work areas, including (i) constructing intercepting ditches and drains to prevent runoff entering construction sites and diverting runoff from sites to existing drainage; (ii) limiting construction and material handling during periods of rains and high winds; and (iii) stabilizing all cut slopes, embankments, and other erosion-prone working areas while works are going on. All earthwork disturbance areas shall be stabilized within 30 days after earthworks have ceased at the sites.

111. **Construction wastewater:** Construction wastewater is produced from the maintenance and cleaning of mechanical equipment and vehicles, maintenance water for mixing and curing concrete, cooling water, and lost water and soil during the construction period which is discharged as pollutants. The effluent, comprised mainly of inorganic wastewater, commonly contains no poisonous and harmful substance, except suspended solid, but, if discharged in an improper manner, still has the potential to impact existing water bodies. Some oil-containing wastewater can arise from machinery repairs.

112. Construction wastewater will not be discharged unto the surrounding soil or into surface water systems. Sedimentation tanks will be built, and after settling out of solids the upper clear liquid will be recycled for spraying the construction site (dust control), and the waste residue in the tank will be cleared and transported to designated landfills. Oil-containing wastewater will require the installation of oil-water separators before the sedimentation tank.

113. **Gaseous air pollution:** Construction machinery on all sites will consume petrol and diesel, releasing gaseous SO_2, CO, and NOx. Equipment will be maintained to a high standard to ensure efficient running and fuel-burning. High-horsepower equipment will be provided with tail gas purifiers. Atmospheric monitoring will be carried out during the construction period. All

vehicle emissions will be in compliance with relevant Cambodian emission standards.

114. **Dust:** Construction sites and access roads will potentially produce fugitive dust from material storage areas, dump sites, concrete mixing, excavation and general site usage – especially under windy conditions. Material stockpiles and concrete mixing equipment will be equipped with dust shrouds. The operators will regularly maintain the shrouds to ensure their effective operation. For both construction sites and construction roads, water spraying for the suppression of dust and maintenance of driving surfaces will be standard site management practice. Vehicles carrying soil, sand, or other fine materials to and from the construction sites will be covered.

115. **Noise:** Noise can be expected during construction due to construction machinery operation and transport activities. Construction activities will involve haulage vehicles, bulldozers, excavators, concrete-mixing plants, rollers, and other heavy machinery. Noise intensity from these large machines operating is typically in the range of 80–90 decibels at the site (5m from operating machinery). The transport of material, aggregate, concrete and waste material to and from sites will also cause noise impacts along the haulage routes. Activities with intensive noise levels will not only have an impact on the residents, but may also cause injury to construction workers operating the equipment.

116. Construction equipment noise source is considered as a point sound source, and the predictive model is as follows:

$$L_A = L_0 - 20\log\left(\frac{r}{r_0}\right)$$

Where, L_A and L_0 are equipment noise sound levels at r and r_0 respectively.

117. According to the model, noise levels at different distances are gained after calculating the impact scope of equipment noise during construction as in Table 18. The Cambodian noise standards for residential areas are used here because many farmhouses are built along the main canals and small commercial villages have developed at the headworks. These mirror IFC EHS standards.

Table 18: Construction Equipment Noise Impact Distance

Level dB (A) / Construction Machinery	Distance							Limit Standard for residential areas dB (A)		Impact Range (m)	
	10	20	40	60	80	100	150	Day	Night	Day	Night
Loader	84.0	78.0	72.0	68.4	66.0	64.0	60.5	60	50	150	300
Bulldozer	80.0	74.0	68.0	64.4	62.0	60.0	56.5	60	50	100	250
Roller	80.0	74.0	68.0	64.4	62.0	60.0	56.5	60	50	100	250
Excavator	78.0	72.0	66.0	62.4	60.0	58.0	54.5	60	50	80	200

118. The results show that, if construction machinery is used singly, the impact distance is 150m away from the source during the day and 300 m at night. Beyond these distances, the noise levels meet Cambodian standards for residential areas. However, it will often be the case that a number of machines will be at use simultaneously during construction, and the noise impact scope will be consequently larger.

119. Activities with intensive noise levels will not only have an impact on the residents, but

also may cause injury to construction workers operating the equipment. Although the noise impacts will be transient and temporary the following mitigation measures are essential for construction activities to meet construction site noise limits and to protect sensitive receptors: Construction at night within 300m of residences shall be strictly prohibited. During daytime construction, the contractor will ensure that: (i) equipment with high noise and high vibration are not used in village or township areas and only low noise machinery or the equipment with sound insulation is employed; (ii) sites for concrete-mixing plants and similar activities will be located at least 1 km away from sensitive areas such as residences and schools; and (iii) temporary anti-noise barriers will be installed to shield any schools, residences and medical centers within 100m of the work sites.

120. **Construction camps solid waste:** The construction contractors will establish site offices and work camps at the headworks' end of the main canals in both subprojects. The construction workforce will generate domestic wastewater and garbage (food wastes, kitchen wastes, paper, and other solid waste including food-laden wash water). Proper disposal of this waste will be essential. It will be the responsibility of the construction contractors to provide toilets with pump-out and disposal facilities and sufficient garbage bins at strategic locations and ensure that they are (i) protected from birds and vermin, (ii) emptied regularly (using the nearest township solid waste system and landfill), and (iii) do not overflow.

121. **Hazardous and polluting materials:** Construction material handling and disposal guidelines and directions that include spill responses will be prepared and implemented as part of the Site Environmental Management and Supervision Manual of each construction site. The following measures will be taken to prevent pollution of soil and surface water/groundwater: (i) storage facilities for fuels, oil, cement, and chemicals will be within secured areas on impermeable surfaces, provided with bunds and cleanup installations; (ii) vehicles and equipment will be properly staged in designated areas to prevent contamination of soil and surface water; (iii) vehicle, machinery, and equipment maintenance and re-fueling will be carried out in such a way that spilled materials do not seep into the soil; (iv) oil traps will be provided for service areas and parking areas; and (v) fuel storage and refilling areas will be located at least 50 m from canals and channels and will be protected by temporary drainage bunds to contain spills.

122. **Flora and Fauna:** All protected areas listed in Chapter IV (Description of the Environment) are more than 50 km away from the subproject sites. The subproject areas have been intensively farmed and irrigated for generations. No natural terrestrial or aquatic habitats exist and natural biodiversity comprises only common wildlife living among humans in agricultural regions, domesticated animals and feral pests and rodents. The vegetation comprises cultivated crops, agricultural weeds and tree plantations along roads, canal banks and dyke walls. There will be no significant loss of native flora and fauna as a result of the Project.

123. **Cultural Heritage:** During construction, contractors will ensure that any local cultural sites (including shrines and graves) will be kept clear of construction material and protected from dust and other disturbance. Access to these sites will not be impeded, and after construction is finished any disturbed surroundings will be restored to pre-construction standards.

D. Environmental Impact and mitigation measures during Operation

1. Hydrological Impacts – Seasonal water Balances

124. The impact of increased water extraction for irrigation on existing water resources has been examined through water balances for the two schemes involving irrigation.

125. **Assumptions.** The assumption for seasonal water balances are based upon theoretical cropping calendars for upland irrigated rice in the subproject provinces. These show two main cropping alternatives:

(i) two short season (90 day) rice crops with the first in the first part of the wet season (May- Aug inclusive) followed by a second short season rice crop beginning in the last part of the wet season and extending into the early dry season (Sept-Dec incl.); and,

(ii) single medium season (130 days) rice crop spanning the main wet season (July-Nov inclusive).

126. Each cropping period includes up to a month's land preparation (pre-saturation and water layer establishment). The alternative cropping is depicted diagrammatically in Figure 27 below and includes the potential for cash crops in conjunction with cropping alternative (ii).

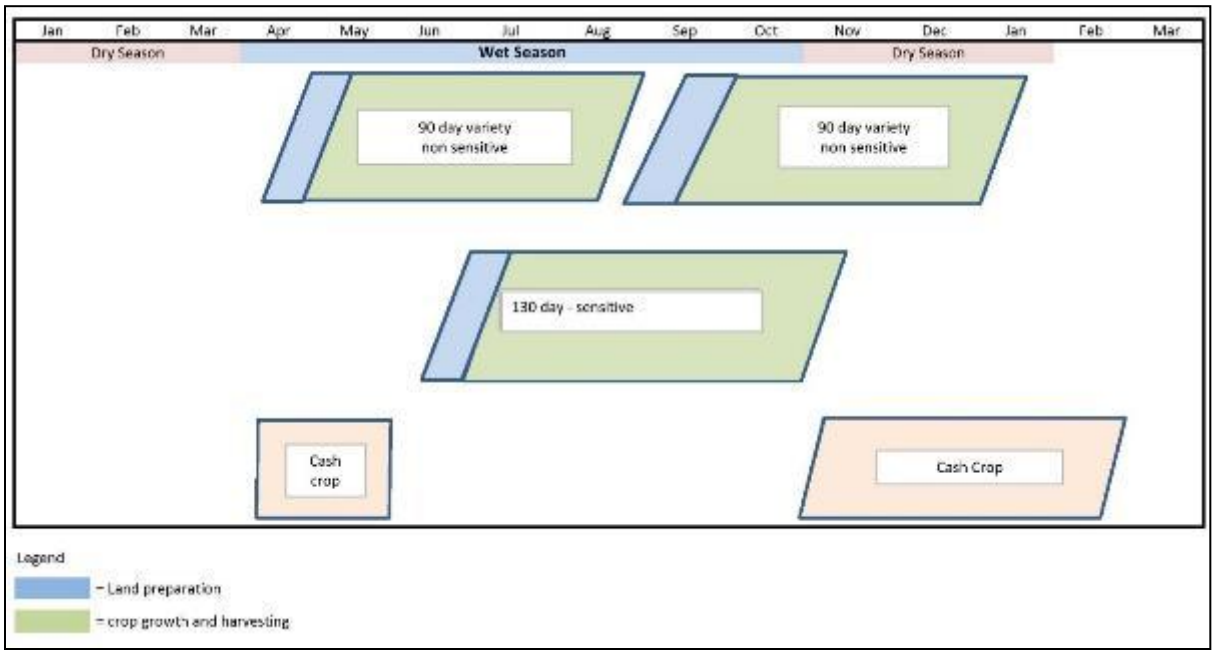


Figure 27: Cropping Calendar for Irrigated Systems

127. The PPTA has derived expected irrigation efficiencies for the project. It concluded that for both core subprojects, in estimating water needs, and resulting water design capacities of main canals, that 40% is a quite reasonable and achievable efficiency.

128. The PPTA also calculated the water needs for the range of cropping alternatives

illustrated above at a range of irrigation efficiencies, and including water requirements for pre-saturation of paddy and establishment of a 100 mm water layer for planting.[5] The water needs are listed in Table 19 below.

Table 19: Irrigation Water Requirements for Different Cropping Alternatives

			Wet Season Efficiency			Dry Season Efficiency		
			50%	40%	30%	50%	40%	30%
			Cu.M/ ha			Cu.M/ ha		
Low Rainfall Yr	Short season Variety	(90 day)	12,000	15,000	20,000	14,500	18,000	24,500
	Med season variety	(130 day)	13,000	16,000	22,000			
Normal Rainfall Yr	Short season Variety		9,000	11,000	15,000	14,000	17,500	23,000
	Med season variety		11,500	14,000	19,000			

Source: PPTA Team

129. The water inflow for the water balances has been taken from the inflow data for Taing Krasaing and Prek Chik calculated by the PPTA team and presented in Table 20 and Table 21 respectively.

130. **Water Balances.** The following seasonal water balances are based upon the scenarios shown in Figure 27 and Table 19, with an irrigation efficiency of 40%. They compare seasonal water needs with water supply for the projected expansion of irrigation areas (total irrigated areas after the project of 9,000 ha for Taing Krasaing and 19,000 ha for Prek Chik (Table 21)).

Table 20: Water Balance for a 9,000 Irrigation Area at Taing Krasaing

	Taing Krasaing		
Wet Season Year	**Crop**	**Water Need (MCM)**	**Water Available (MCM)**
Low rainfall year	Short season variety (May-Aug) 90 day+	135	188
	Medium season variety (July-Nov) 130 day+	144	473
Normal rainfall year	Short season variety (May-Aug) 90 day+	99	185
	Medium season variety (July-Nov) 130 day+	126	363
Dry Season			
Low rainfall year	Short season variety (Sept-Dec) 90 day+	162	277
Normal rainfall year	Short season variety (Sept-Dec) 90 day+	157.5	400

[5] PPTA Mid-Term Report, Appendix 4.

Table 21: Water Balance for a 19,000 Irrigation Area at Prek Chik

Prek Chik			
Wet Season Year	**Crop**	**Water Need (MCM)**	**Water Available (MCM)**
Low rainfall year	Short season variety (May-Aug) 90 day+	285	105
	Medium season variety (July-Nov) 130 day+	304	239
Normal rainfall year	Short season variety (May-Aug) 90 day+	209	91
	Medium season variety (July-Nov) 130 day+	266	314
Dry Season			
Low rainfall year	Short season variety (Sept-Dec) 90 day+	342	150
Normal rainfall year	Short season variety (Sept-Dec) 90 day+	332.5	256

Note: 90 day+ and 130 day+ refers to the growing period plus land preparation;
Source: PPTA team.

131. The shaded cells in the water balance show where water availability is sufficient for irrigation needs. The balance for Taing Krasaing shows that all cropping alternatives are sustainable and that surplus water exists for cash crops in addition to rice. The surplus of available water also indicates that other beneficial users of the water, either at the reservoir or directly from the main canal will not be disadvantaged.

132. For Prek Chik however the water balance indicates that only a 130 day (medium) crop grown July-November in a normal rain year is sustainable over the projected irrigation area. If the command area was smaller, more cropping options would become possible for the available water. However, the results for Prek Chik indicate that water is a significantly limiting factor and any level of irrigation use will have the potential to impact on other beneficial water uses.

133. To ensure that the irrigation schemes will be sustainable and responsibly managed, and that agreed irrigation and base flows are maintained and other beneficial water users are not disadvantaged, a clear and detailed extraction plan for the growing seasons will be prepared by the PMU in consultation with FWUCs, as a prerequisite for project commencement. This will be part of the larger Joint Reservoir Operations Plan (JOROP) which will be developed by the PMU and FWUCs in collaboration with the PPTA Team. Operational plans and operating practices for water allocations and drainage will be documented and approved by the PMO and ADB before procurement and construction commences.

2. Impacts from Intensification of Agriculture

134. The benefits resulting from the project's irrigation and drainage facilities will accrue to the beneficiaries through both intensification and expansion of agriculture in the areas. With an increase in agriculture comes a potential increase in the use of agricultural chemicals.

135. At current application rates of approved chemicals the following increases in fertilizer and pesticide applications can be expected from the increases in agricultural activity (see Table 22 below). The increase in agricultural activity is based upon the maximum cultivation of each subproject area based upon available water (see water balances) – this is two short season rice crops and a cash crop at Taing Krasaing and one medium period rice crop at Prek Chik.

Table 22: Fertilizer and Pesticide Use Before and After the Project

Province	Subproject	Component	Cultivated land (ha)		Change	Increment of fertilizer (ton/year)	Increment of pesticides (litre/year)
			Without project	with project			
Kampong Thum	Taing Krasaing irrigation system	Irrigation	1,400	9,000	7,600	1520	76,000
Battambang	Prek Chik irrigation system	Irrigation	6,000	19,000	13,000	1,300	65,000
Total increment of Fertilizer & pesticides						2,820	141,000

Note: Average fertilizer use: 0.1 tons/ha/crop
Irrigation area: 2 crops per year for Taing Krasaing and 1 crop per year for Prek Chik
Average pesticide use: 5.0 litre/ha/yr

136. The predicted incremental increase of fertilizer use for the whole Project is 2,820 tons per year, and the increment increase in pesticide use is 141,000 litres per year. Nitrogen and phosphorus in liquid effluents can contribute to eutrophication in water and risk of oxygen depletion in waterbodies. Excessive nitrogen as ammonia can lead to gradual acidification of soils. Organochlorines, organophosphates, pyrethroids and carbamates (the common pesticide types used) can lead to direct poisoning of farmers through misuse and unsafe handling. Organochlorines and organophosphates can enter the food chain and groundwater resources.

137. Farmer surveys carried out by the PPTA team found that only 10% of farmers have received training in Integrated Pest Management (IPM), and that 80% of all farmers apply fertilizer, but that applications are not based on specific soil/crop needs. To address this, the Project will deliver, as part of its Capacity Building and Training component, training modules specifically tailored to the needs of farmers on IPM and low chemical cultivation applicable to cropping conditions and capacities in the subproject areas. Training in IPM will coordinate with the Cambodian National IPM Programme and include the safe storage, handling and disposal of agricultural chemicals. The Project will also undertake soil analyses in the command areas and provide farmers with recommendations on appropriate fertilizer regimes and cultivation practices.

138. The training package will emphasise environmentally sound farming and sustainability and will provide farmers with alternative approaches to a reliance on chemicals.

E. Environmental Health and Safety

139. Safety and health of both workers and residents may be threatened by construction activities. Numerous workers will gather within the construction site, with potentially relatively low living conditions such as unclean water, poor food, and increased risk of diseases infection and transmission. Surrounding residents may also be affected by noise and dust. Workers will confront construction safety risks as well.

140. Measures to protect the community will include:

(i) Planning construction activities (including demolition work) so as to minimize disturbances to residents, utilities and services. Temporary land occupation will be planned well ahead of construction to minimize its impact. Land will be reinstated to its original condition after construction.

(ii) Implementing safety measures around the construction sites to protect the public,

including warning signs to alert the public to potential safety hazards, and barriers to prevent public access to construction sites and unsafe areas.

141. Measures to ensure occupational health and safety will include:

(i) Contractors shall be required by the PMUs to ensure that their workers and other staff engaged in the proposed constructions are in a safe environment.

(ii) Following the award of construction contracts, the successful contractors will prepare site environmental health and safety plan, for approval by the PMUs.

(iii) Contractors shall ensure that: (a) all reasonable steps are taken to protect any person on the site from health and safety risks; (b) the construction site is a safe and healthy workplace; (c) machineries and equipment are safe; (d) adequate training or instruction for occupational health and safety is provided; (e) adequate supervision of safe work systems is implemented; and (f) means of access to and egress from the site are without risk to health and safety.

F. Unanticipated Impacts during Construction and Operation

142. If any unanticipated impacts become apparent during project implementation, the borrower will (i) inform and seek ADB's advice; (ii) assess the significance of such unanticipated impacts; (iii) evaluate the options available to address them; and (iv) prepare or update the EIA including EMP. ADB will help the borrower mobilize the resources required to mitigate any adverse unanticipated impacts or damage.

G. Climate Change Impact Assessment

143. The environmental risks from climate change need to be addressed in two different but complementary ways: (i) consideration of greenhouse gas emissions; and (ii) adaptation to safeguard infrastructure against the effects of future climate change.

1. Greenhouse Gas Emissions

144. Net greenhouse gas emissions from the project will derive from GHGs emitted by agricultural activities – in particular the CH_4, N_2O and CO_2 emissions from rice paddy flooding and cultivation. The greenhouse gas emissions from rice paddy fields have been studied in India, Philippines and Japan (Table 23), and to a lesser extent in China and the USA. Only the studies in northern India have studied the emission of the suite of GHGs (CH_4, N_2O and CO_2) in combination with different ranges of nitrogen fertilizer applications and on a range of soils. Studies have also compared the GHG emission consequences of different periods of inundation of rice crops.

Table 23: GHG Emissions from Rice Paddy

Location	Methane (CH_4) from Rice Paddy
Northern India[6]	40 – 100 Kg/ha
Philippines[7]	100 – 150 Kg/ha
Japan[8]	150 – 200 kg/ha

[6] Pathak H, C Li and R Wassmann (2005)
[7] Corton et al (2000)
[8] Yagi et al (1996)

145. The Indian study approximates the subproject conditions for comparable levels of fertilizer application and temperatures. The yearly emission levels used for this project are therefore:

66 kg/ha CH_4 : 690 kg/ha CO_2 : 1.93 kg/ha N_2O.

146. These emission rates are calculated for the Project area in Table 24, and converted into equivalent levels of CO_2 using the following formula:

*Global warming potential (GWP) = CO_2 emissions + CH_4 emissions*21 + N_2O emissions*310*

Table 24: GHG Emissions and GWP from Rice Paddy Increases

Increase in Rice Paddy (ha)	CH_4 emissions (kg/yr)	CO_2 emissions (kg/yr)	N_2O emissions (kg/yr)		GWP (tons/yr CO_{2e})
		Taing Krasaing			
7,600	501,600	5,244,000	14,668		20,325
		Prek Chik			
13,000	858,000	8,970,000	25,090		34,766
				Total	**55,091**

147. The total CO_{2e} emissions generated by the project will be approximately 55,000 tons/annum. This is below the threshold of 100,000 tons/annum where the ADB SPS (2009)[9] and therefore, no further monitoring is required.

2. Adaptation to Future Climate Change

148. Climate change is expected to alter the current runoff and rainfall regimes. Climate change assessments for Cambodia indicate greater but more variable rainfall, increased crop water demand, more frequent and severe floods, droughts and wind storms[10].

149. Most of the increase in average annual rainfall predicted by models is expected to occur in the already wet months of the year, with only a minor or no increase over the dry season. The higher temperatures will increase crop water demands. These climate changes have the potential to influence both dry and wet season flow in the Project area, and this is examined below.

150. The predicted changes in rainfall and temperature under climate change scenarios (see Section IV) will combine to affect future irrigated water requirements (IWR). Figure 27 below shows predicted IWR for all SRES projections for nation states acting in isolation (A2 and B2 scenarios).

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[9] Which requires an annual quantification of GHG emissions in accordance with internationally recognized methodologies.

[10] Tes, S. Jan 2015. Assessment of Water Resources for Improved Water Governance under Climate Change: Stung Chinit River Catchment. Presentation to Third Steering Committee Meeting Climate Change and Water Governance in Cambodia 20 January 2015 , Cambodiana Hotel, Phnom Penh

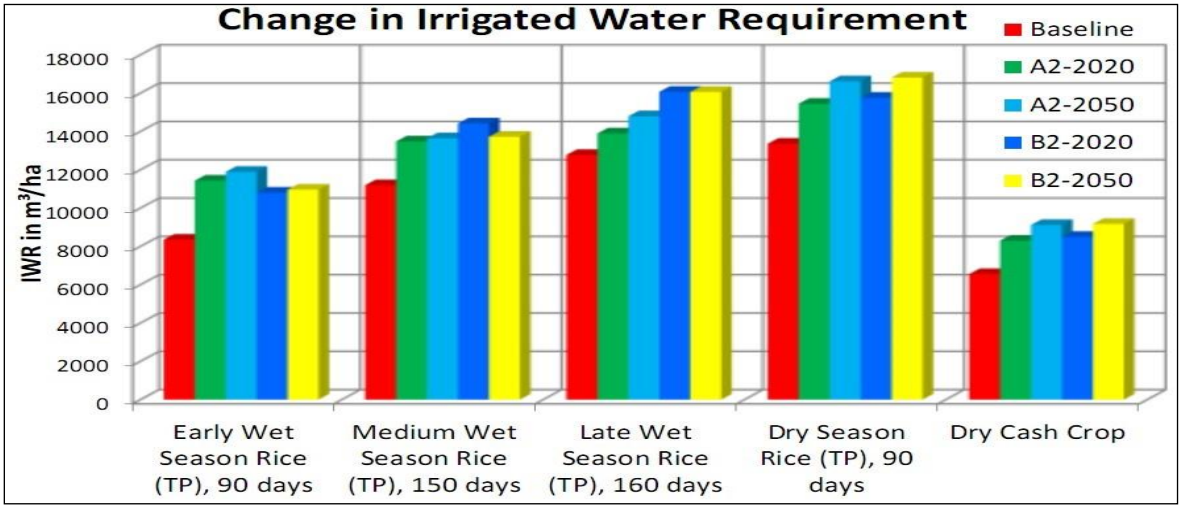
151. The crops of interest for Taing Krasaing are early wet season rice and late wet/dry season rice (both 90 day crops). For Prek Chik the relevant crop is medium wet season rice. The projections in Table 25 show that IWR for these crops will be in the following ranges in 2020 and 2050:

Table 25: Predicted IWRs from Climate Change and IWRs used in Subproject Water Balances

Crop	Predicted IWR in 2020 (m^3/ha)	Predicted IWR in 2050 (m^3/ha)	IWR used in Water Balances (Tables 21 and 22) for dry years (m^3/ha)
Early wet season rice	10,000-12,000	10,000-12,000	15,000
Late wet/dry season rice	15,000-16,000	16,000-17,000	18,000
Medium wet season rice	13,000-14,200	13,000-14,000	16,000

Source: PPTA Team.

Figure 27: Irrigation water requirements from IPCC SRES



Source: Sopharith, 2015

152. Table 25 shows that when the IWRs from future climate change scenarios are compared with the IWRs being used for subproject design the project design IWRs are consistently higher and already allow for the eventuality of future increased water demand in both 2020 and 2050.

153. Increase in rainfall is predicted in future scenarios for 2020 with a decrease to near present levels in 2050. The need to drain wet season flooding of cultivation areas will therefore be highlighted in the short to medium term. The design of works to the main canals of the two core subprojects includes refurbishment of all cross drainage structures (which drain flood water). The majority of these have been inoperative for many years and their restoration to working order will alleviate local flooding and predicted flooding.

154. Design of structures for significantly higher flood return periods have been incorporated in subproject planning. Canal walls will be reconstructed where needed and strengthened to withstand the above design flood flows. Headworks spillways, sluice gates and weirs will be provided with erosion/scour protection to maintain the integrity of control structures against high energy flood flows. The crest height of control gates will be adjusted above the 1 in 100 year level to direct flood waters to control release sluices rather than overtopping and scouring.

155. Typical canal rehabilitation along high flow sections will involve replacement of structurally unsuitable material combined with an installed lining inside the canal slopes. This will retain a natural canal bed and benthic environment for the limited canal fisheries but protect side walls from flood scouring and failure.

156. The initial rapid environmental assessment (REA) undertaken by the ADB during project planning identified a medium climate risk. Therefore a Climate Risk and Vulnerability Assessment (CRVA) has been undertaken for the core subprojects (Appendix 2).

VI. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

A. Consultation and Participation Process

157. Public consultation was undertaken by the PPTA team at the Taing Krasaing and Prek Chik Irrigation Schemes from 11 to 19 March 2014. The consultation was a combined information dissemination, agricultural and irrigation conditions data collection, and environmental investigation.

158. Meetings were held with individual farmer communes as set out in Table 26 below. The format of the meetings was a presentation of the project by the PPTA team followed by open discussion and the filling out of questionnaires. A summary of environmental issues raised both during discussion and in the questionnaires is given in Table 27.

Table 26: Profile of Participants in Public Consultation

Date	Commune	Total farmer Attendees	Female	Peoples from villages
Taing Krasaing Scheme				
11/3/2014 am	Taing Krasaing	29	16	Vaing Khang Chhoeung village
11/3/2014 pm	Tipor	26	15	Tipor village and Nimith villages
12/3/2014 am	Chrob	32	17	Chey Mongkul and Sdok Sdam villages
12/3/2014 pm	Krakoh	25	17	Chi Meak and Santuk Krao villages
Total	4	112	65	
Prek Chik Scheme				
17/3/2014 am	Prek Chik and Bassac	37	9	Siem village, Chhker Kham Pres, Khnach Ampor, Preak Chik, and Snam village
17/3/2014 pm	Prey Trolach	43	28	Chong Ampor and Prey Khlot villages
18/3/2014 am	Mouk Reah	58	37	Toul Svay, Mouk Reah I, Mouk Reah II villages
18/3/2014 pm	Sdok Pravoeuk	16	6	Prah Andong, Toul Korki villages
19/3/2014 am	Ruissey Kraing	24	0	Toul Roka, Chrey Ron villages
19/3/2014 pm	Svay Prey and Kea	43	22	Run, Thnal Bambek villages
Total	**8**	**221**	**102**	

Table 27: Environmental/Agricultural Issues arising from Public Consultation

Scheme	Issues arising from Public Consultation
Taing Krasaing communes	• No water and no functioning secondary and tertiary irrigation canals to serve farmers. • Rain-fed rice areas are not properly leveled and most of soils are very poor with low productivity. • Poor technical practice for land preparation, planting method (all broadcast), weed control, pest control with wrong decision of farmers in selecting chemicals without recommendation from agricultural extension workers. • Poor technical transfer between farmers and agricultural extension

	workers and also from farmers to other farmers because lack training place in village and lack of field demonstration. • Farmer's agro-technical knowledge is limited in rice production and livestock production. • Lack of Agro-technical training to farmers in place including rice and livestock.
Prek Chik communes	• No water and no functioning secondary and tertiary irrigation canals to serve farmers. • Soils are very poor (unfertile) with low productivity. • Poor technical practice for land preparation and planting method (all broadcast). • No proper method in weed control, pest control. Poor decision-making of farmers in selecting agro-chemicals. • Lack of training/meeting location. Support the establishment of a training hall in each target village • Farmer's agro-technical knowledge is limited in rice production and livestock production.

B. Project Responses

159. Similar issues concern farmers in both schemes. The project will meet the farmers' water needs by its major works of canal rehabilitation (although provision of secondary and tertiary canals along with their water regulating infrastructure will await implementation of long list subprojects).

160. The project will also address the issues of farmer training in rice agronomy and livestock. Training as recommended in the IEE and included in the EMP training requirements will focus among on integrated pest management (to guide pesticide application) and use of soil chemistry and crop needs to guide fertilizer use.

VII. GRIEVANCE REDRESS MECHANISM

161. A grievance redress mechanism (GRM) will be established in each subproject province in compliance with ADB's SPS (2009) requirement to prevent and address community concerns and assist the project to maximize environmental and social benefits.

162. The GRM will be accessible to diverse members of the community, including more vulnerable groups such as women and youth. Multiple points of entry, including face-to-face meetings, written complaints, telephone conversations, or e-mail, will be available. Opportunities for confidentiality and privacy for complainants will be honored where this is seen as important.

A. Proposed Mechanism

163. The PMU will establish a Project Public Complaint Unit (PPCU) which will act as a central recording and coordinating unit for all subprojects under the Project. Each subproject PMU will ensure that the GRM is publicized locally so that the community is fully aware of the mechanism and the local points of entry to it. The setting up of the GRM in the PMU and its initial implementation through the PMUs will be supported by the environmental consultant of the PMIC.

164. When construction starts, a sign will be erected at each construction site providing the public with updated project information and summarizing the grievance redress mechanism process including details of the GRM entry points. The contact persons for different GRM entry points; PMU, FWUC leaders, contractors, and operators of project facilities, will be identified prior to construction. The contact details for the entry points (e.g. phone numbers, addresses, e-mail addresses, etc.) will be publicly disseminated on information boards at construction sites and on the website of the local government.

165. The preferred action sequence for complaints handling is that the complaint should be investigated and resolved by the unit receiving the complaint. If this is not possible, the complaint should be referred to the PMU (whose wider membership will enable coordinated action in response).

166. The PPCU will maintain records of complaints and actions taken to correct them. This data will be included in the PMU's reports to the ADB. The PPCU will establish a GRM tracking and documentation system. The system will include the following elements: (i) tracking forms and procedures for gathering information from project personnel and complainant(s); (ii) staff to update the database routinely; (iii) systems with the capacity to analyze information so as to recognize grievance patterns, identify any systemic causes of grievances, promote transparency, publicize how complaints are being handled, and periodically evaluate the overall functioning of the mechanism; (iv) processes for informing stakeholders about the status of a case; and (v) procedures to retrieve data for reporting purposes, including the periodic reports to the ADB.

B. GRM Procedure and Timeframe

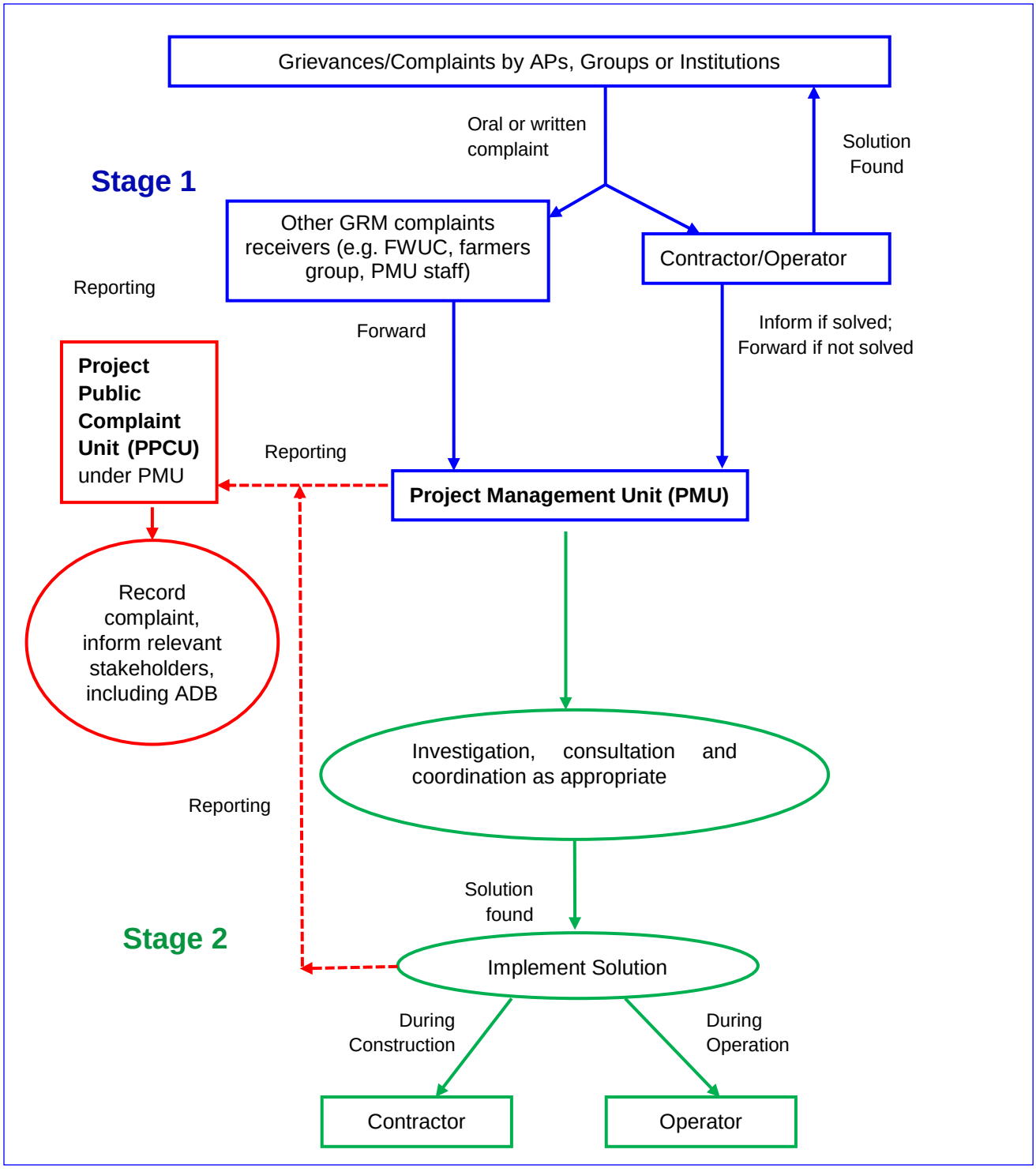
167. The procedure and timeframe for the grievance redress mechanism are described as follows (see Figure 29). The stages are represented by different colours in the flow diagram:

(i) **Stage 1:** If a concern arises during construction, the affected person will submit a written

or oral complaint to the contractor directly. Whenever possible, the contractor will resolve the issue directly with the affected person. The contractor will give a clear reply within one week. If successful, the contractor will inform the PPCU accordingly.

(ii) **Stage 2:** If no appropriate solution can be found, the contractor should forward the complaint to the PMU within five (5) working days. The complainant may also decide to submit a written or oral complaint to the PMU, either directly or via one of the GRM entry points (FWUC or other farmers representative groups). The PMU will investigate and identify the solution and provide a clear reply for the complainant within five (5) working days. The environment consultants of the PMIC will assist the PMU in replying to the affected person. The PMU will timely convey the complaint/grievance and suggested solution to the contractors or operators of facilities. The contractors during construction and the operators during operation will implement the agreed upon redress solution and report the outcome to the PPCU within seven (7) working days.

168. During construction, the PPCU will be informed by contractors and construction supervisors, FWUC staff, or PMUs if people complain about the project. During operation, the PPCU will be advised of complaints by the PDWRAM and FWUC.The PPCU will also inform the ADB project team and submit all relevant documents.



Note: AP = affected person; PMU = Project management unit; FWUC = Farmer water user commune.

Figure 29: Concept of Proposed GRM

VIII. CONCLUSION AND ASSURANCES

A. Positive Impact and Environmental Benefits

169. The result of the subproject irrigation facilities will be (i) an increase in certainty and control of existing irrigation areas; (ii) expansion of irrigation into new areas; and (iii) winning of longer or new cropping periods on areas previously unavailable for parts of the year due to flooding.

170. In terms of areas sown, the subprojects will increase potential rice growing areas by 84% in the Taing Krasaing scheme and 68% in the Prek Chik scheme. The beneficiaries of these changes will be local farmers, with flow-on effects to local commercial enterprises. Since rural populations are the poorest sectors of the Cambodian population, poverty alleviation effects will be direct and sustainable.

B. Negative Impacts

171. During construction, the main issues will be air and water pollution and soil erosion, all of which must be managed by strict control of construction contractors. Additional localised traffic hazards are anticipated and this must be minimised by site access and road safety planning. Health and safety of construction workers is also, as always, a primary concern. Mitigation of construction-phase impacts relies heavily on responsibility of works contractors to follow specification clauses specifically designed to minimise pollution of air and water and soil erosion. This mitigation will in turn rely on enforcement by the Environmental Management Officer in each project management unit and also by construction supervision consultants.

172. Post-construction, the main concerns are local increases in the levels of agricultural fertiliser and pesticide residues and their effects on water quality and people. Post-construction mitigation will benefit from capacity building and training under the project to use fertilisers and pesticides efficiently and responsibly.

173. There is also a concern that the irrigation schemes must be sustainable and responsibly managed, to ensure that agreed irrigation flows are maintained and other water users are not disadvantaged. The EMP requires a clear and detailed extraction plan for the cropping seasons to be prepared as part of each scheme's JOROP and submitted before construction.

C. Assurances

174. The most important assurance, which should be guaranteed by a loan covenant is that the PMUs will undertake the full range of effective measures set out in the IEE and EMP to ensure that the environmental management provisions and the environmental monitoring plan will be implemented effectively during project implementation, and that the implementation reports of the environmental management and monitoring plan in accordance with ADB requirements will be submitted in a timely fashion. Part of this monitoring and management commitment will be a commitment to implement and maintain an appropriate Grievance Redress Mechanism covering the construction and operation of the subprojects.

175. Other, specific assurances are that:

(i) The sediment quality of spoil from channel dredging will need to be tested and assessed against the relevant standards before reuse. The sediment testing results will determine the requirements to ensure safe reuse.

(ii) The Project will deliver, as part of its Capacity Building and Training component, training modules specifically tailored to the needs of farmers on Integrated Pest Management (IPM) and low chemical cultivation applicable to cropping conditions and capacities in the local soil and climatic environments.

D. Conclusion

176. The majority of identified environmental impacts are not assessed as significant. It is concluded that the infrastructure subprojects planned for the Taing Krasaing and Prek C schemes have significant potential benefits for the rural populations of these areas. It is concluded that the design features, operational regimes and construction management safeguards will address the range of potential environmental impacts identified and will be actioned through the Project EMP and continuously checked in the environmental monitoring program.

APPENDIX 1: ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

1. The environmental management plan (EMP) covers all phases of core subproject implementation from preparation through commissioning and operation, and it aims to ensure the monitoring of environmental impacts and activation of environmental mitigation measures. Relevant parts of the EMP will be incorporated into the construction, operation, and management of each subproject. Environmental protection measures will (i) avoid, and (ii) where avoidance is not possible, mitigate environmental impacts, and (iii) achieve compliance with national environmental regulations and ADB safeguard Policy statement 2009.

2. Environmental monitoring programs will be carried out and the results will be used to evaluate the extent and severity of actual environmental impacts against the predicted impacts and the performance of the environmental protection measures.

B. Responsibilities for Implementation

3. The Ministry of Water Resources and Meteorology (MOWRAM) is the executing agency (the EA) and Department of Farmer Water User Community (DFWUC) is the implementing agency (the IA). A Project Steering Committee, headed by Minister MOWRAM, will oversee the Project implementation and management. A Project Management Unit (PMU) was established before start of the PPTA and the PMU was fully involved in the Project preparation. The PMU is headed by a Project Director who is the Deputy Director General for Technical Affairs and a Project Manager who is the Director of the Department of FWUC. The PMU is composed of 24 designated personnel from MOWRAM, MAFF and PDWRAM. This will also include staff from the PDWRAM of the province within which the subproject is located. For the Taing Krasaing and Prek Chik subprojects the PMU will be:

4. The supervision and monitoring of project-related environmental activities during the pre-construction, construction and operation phases are the functions of the PMU. In line with this an Environmental Management Officer (EMO) in the PMU will be assigned to be responsible for supervision of environmental management and for environmental monitoring. The major responsibilities of the environmental officer will be to ensure that:

(i) Mitigation measures and monitoring of these activities are carried out in accordance with the EMP;
(ii) Environmental monitoring program, comprising the of taking samples and analysis are being carried out;
(iii) Reporting is performed in compliance with ADB and GOKC requirements.

5. However, the main environmental guidance for the implementation phase will be provided by a the Environment Specialist in the Project Management and Implementation Consultants (PMIC) team The role of the PMIC will be to work as part of the PMU, helping them fulfil their supervision and monitoring responsibilities. The PMIC will also provide monitoring reports for the ADB. The PMIC will be contracted by the PMU for the duration of the loan implementation period.

6. Contractors will be engaged by the PMU for construction. The construction impact mitigation measures contained in this EMP will be included as necessary activities in the contract documents. The incorporation of EMP provisions into the contract documents will be

undertaken by the PMU. The contractors will have the responsibility for implementing the impact mitigation measures in the construction phase and their performance will be supervised by the PMU.

7. Environmental monitoring during operation of the Project in the longer term is the responsibility of the Kampong Thom and Battambang PDWRAMs.

C. Summary of Potential Impacts

8. Table A1.1 summarizes the potential impacts of the subprojects during construction and operation as identified by the initial environmental examination (IEE), as well as corresponding mitigation measures designated to minimize those impacts.

1. Mitigation Measures

9. The mitigation measures will be incorporated into tender documents, construction contracts, and operational management procedures. Contractors and PMU and PDWRAMs will implement these measures, depending upon subproject phases. The effectiveness of these measures will be carefully watched via the environmental monitoring to determine whether to continue them or to make improvements.

Table A1.1: Summary of Potential Impacts and Mitigation Measures

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
Pre-construction						
1.1 Design stage	Final site designs	Final designs of canals, siting of control structures and canal alignments will be completed after taking into account the provisions of the EMP.	PMIC	PMU	Design costs	
	Irrigation extraction planning	Operational plans and operating practices for water allocations and drainage will be documented and approved by the PMU and ADB before completion of construction works and handing over of canals to FWUCs. This will be part of the Joint Reservoir Operations Plans (JROP).	PMU, FWUCs and PMIC	PMO, ADB	Design costs	
	Baseline water quality	Establish baseline water quality for surface water (see monitoring plan)	PMIC	PMU	Included in monitoring costs	
1.2 Construction Preparation Stage	Environmental management budget	Confirm budgets for the implementation of environmental management measures and environmental supervisory responsibilities. Assign final budget allocations against each of the items in the EMP	PMU	PSC	Design costs	
	Update EMP	Updating EMP: Mitigation	PMIC	PMU	Design costs	

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
		measures defined in this EMP will be updated and incorporated into the detailed design to minimize adverse environmental impacts.				
	Incorporate environmental management into contract documents	Contract documents: Preparation of the environment section in the Terms of Reference for bidders for construction contracts, and environmental contract clauses for contractors, namely the special conditions for the protection of the water, soil and air environments (referencing the EMP and monitoring plan).	PMIC	PMU	Design costs	
1.3 Construction support preparation	Environmental education and awareness	Environmental Protection Training: Environmental specialists (including PMIC) and/or officials from local MOE offices will be invited to provide training on implementation and supervision of environmental mitigation measures to PMU and PDWRAMs.	PMIC and MOE officers as required	PMU	Included in Project training budget	
		Environmental Protection Training: EMO, PMIC and/or officials from local MOE offices will be invited to provide training on implementation and supervision of environmental mitigation measures to contractors.	PMU and PMIC	PMU	Part of EMP training costs	
					10,950	4,050
	Complaints procedures established	The Project Grievance Redress Mechanism will be established and local contact points for the subprojects publicized	PMU and PMIC	PSC	Part of Design costs	
	Site planning	Prepare a Site Environmental Management and Supervision Manual, including an emergency preparedness and response plan for construction emergencies and site environmental health and safety plan.	Contractors	PMU and PMIC	Part of construction costs	
					7,300	2,600
Construction						
2.1 Water	Pollution from construction wastewater	Construction wastewater from the main construction sites will not be discharged onto the surrounding soil or into surface water systems (canals). Sedimentation tanks will be provided, and after settling out of solids the upper clear liquid will be recycled for spraying the	Contractors	PMU and PMIC	18,250	6,750

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
		construction site (dust control), and the waste residue will be transported to disposal sites where they will not contaminate agricultural soils or waterways. Oil-containing wastewater will require the installation of oil-water separators before the sedimentation tank.				
	Hazardous materials	To prevent pollution of soil and surface water/groundwater: (i) storage facilities for fuels, oil, cement, and chemicals will be within secured areas on impermeable surfaces, provided with bunds and cleanup installations; (ii) vehicle, machinery, and equipment maintenance and re-fueling will be carried out in such a way that spilled materials do not seep into the soil; (iii) oil traps will be provided for service areas and parking areas; (iv) fuel storage and refilling areas will be located at least 50 m from canals and channels and will be protected by temporary drainage bunds to contain spills.	Contractors	PMU and PMIC	10,950	4,050
2.2 Air	Air quality	Equipment will be maintained to a high standard to ensure efficient running and fuel-burning. High-horsepower equipment will be provided with tail gas purifiers. All vehicle emissions will be in compliance with relevant Cambodian emission standards.	Contractors	PMU and PMIC	3,650	1,350
	Dust	Material stockpiles and concrete mixing equipment will be equipped with dust shrouds. For both construction sites and construction roads, water spraying for the suppression of dust and maintenance of driving surfaces will be standard site management practice. Vehicles carrying soil, sand, or other fine materials to and from the construction sites will be covered.	Contractors	PMU and PMIC	7,300	2,600
2.3 Noise and Vibration	Noise impacts on sensitive receivers	Construction at night within 280m of residences shall be strictly prohibited. During daytime construction, the contractor will ensure that: (i) sites for concrete-mixing plants and similar activities will be located at least 1 km away from residences and schools; and	Contractors	PMU and PMIC	7,300	2,600

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
		(ii) temporary anti-noise barriers will be installed to shield any schools or residences within 100m of the construction site.				
2.4 Solid wastes	Demolition waste	Any waste from the demolition of unrepairable sluice and gate structures will be either sold to building material recyclers or collected and transported to official landfill sites. Metal parts, including pumps and pipes will be broken up and sold to scrap metal merchants. Any excess spoil will be made available to nearby communities for use as building pads and bunds.	Contractors	PMU and PMIC	3,650	1,350
	Dredge spoil	The sediment quality of spoil from channel clearing or dredging will need to be tested and assessed for contamination before reuse. The sediment testing results will determine the requirements to ensure safe disposal or reuse.	PMIC	PMU	18,250	-
	Waste from worker camps	Contractors will provide toilets with pump-out and disposal facilities and sufficient garbage bins at strategic locations and ensure that they are (i) protected from birds and vermin, (ii) emptied regularly (using the nearest township solid waste system and landfill), and (iii) do not overflow	Contractors	PMU and PMIC	3,650	3,650
2.5 Soil erosion and ecology		Erosion control will include: (i) limiting construction and material handling during periods of rains and high winds; and (ii) stabilizing all cut slopes, embankments, and other erosion-prone working areas while works are going on. All earthwork disturbance areas shall be stabilized within 30 days after earthworks have ceased at the sites.	Contractors	PMU and PMIC	18,250	6,750
2.6 Social and Cultural	Impacts to local cultural sites	Contractors will ensure that all local cultural sites (including shrines and graves) will be kept clear of construction material and protected from dust and other disturbance. Access to these sites will not be impeded. After construction is finished any	Contractors	PMU and PMIC	-	-

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
		disturbed surroundings will be restored to pre-construction standards.				
2.7 EHS	Community health and safety	Community health and safety will be safeguarded by: 1) Planning construction activities so as to minimize disturbances to residents, utilities and services. Temporary land occupation will be planned well ahead of construction to minimize its impact. Land will be reinstated to its original condition after construction. 2) Implementing safety measures around the construction sites to protect the public, including warning signs to alert the public to potential safety hazards, and barriers to prevent public access to construction sites.	Contractors	PMU and PMIC	3,650	1,350
	Occupational health and safety	Measures to ensure occupational health and safety will include: Contractors shall be required by the PMU to ensure that their workers and other staff engaged in the proposed constructions are in a safe environment; Following the award of construction contracts, the successful contractors will prepare site environmental health and safety plan, for approval by the PMU; Contractors shall ensure that: (a) all reasonable steps are taken to protect any person on the site from health and safety risks; (b) the construction site is a safe and healthy workplace; (c) machineries and equipment are safe; (d) adequate training or instruction for occupational health and safety is provided; (e) adequate supervision of safe work systems is implemented; and (f) means of access to and egress from the site are without risk to health and safety.	Contractors	PMU and PMIC	18,250	6,750
2.8 Unexpected environmental		If unexpected environmental impacts occur during project	PMU and PMIC	PSC	Contingency	

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Costs (US$)	
					TK	PC
impacts		construction phase, the PMU will update the EMP, and environmental protection measures will be designed and resources will be utilized to cope with these impacts			3,650	1,350
Operation						
3.1 Management of Irrigation	Implementation of extraction and drainage plans	Irrigation schemes to be operated strictly in concurrence with extraction and irrigation plans which ensure sustainability of supply.	PDWRAM and FWUCs	PMU	7,300	2,700
	Canal fisheries	Informal canal fisheries rights safeguarded for local farmers	FWUCs	PMU	-	
3.2 Training in IPM and sustainable farming		The Project will support the national Integrated Pest Management program and deliver IPM training modules and low chemical cultivation training modules applicable to cropping conditions and capacities in the Project sites.	PMIC	PMU	Part of EMP training costs	
					29,200	17,550
3.3 Emergency response Planning	Floods and extreme weather events	The Project will promote the development of community based disaster readiness programs at the irrigation and drainage communes with particular reference to flooding and other natural disasters.	Project output	ADB	7,300	2,700

TK = Taing Krasaing; PC = Prek Chik; PMU = Project Management Unit (of PMO); PMO = Project Management Office; EMO = Environmental Management Officer (of PMU); PDWRAM = Provincial Department of Water Resources and meteorology; ADB = Asian Development Bank; MOE = Ministry of Environment; PMIC = Project Management and Implementation Consultant; FWUC = Farmers Water User Commune; PSC = Project Steering Committee.
Source: PPTA Team

2. Environmental Management Costs

10. The costs of implementing the environmental management and impact mitigation measures listed in the EMP matrix (Table A1.1) are included in the design costs, construction contracts and operational budgets. Final budget allocations against each of the items in the EMP will be developed by the PMU.

D. Environmental Monitoring

1. Monitoring Program

11. The Project monitoring program will focus on the environment within the Project's area

of influence. An environmental monitoring program is summarized in Table A1.2 below. The program considers the scope of monitoring and frequency. The monitoring results will be assessed against the following standards and corrective management implemented in cases of non-compliance.

(i) The sub-decree No 27 ANRK.BK on Water Pollution Control is dated on April 6th, 1999. (Table for Lake and Reservoir)
(ii) The sub-decree No 36 ANRK.BK on Solid Waste Management is dated on April 27th, 1999.
(iii) Ministry of Industry Mines and Energy Drinking Water Quality Standards, January, 2004

12. For the re-use and disposal of silt from canal cleaning or dredging, there is no RGC standard, and standards applying to paddy field environments from China and Japan will be referenced.[1]

Table A1.2: Environmental Monitoring Plan

Parameters	Location	Frequency	Responsibility
Pre-Construction			
Surface water quality: pH, SS, EC, NH_4+, NO_3- , $PO_{4\ 3}$-, DO, BOD5, COD, Oil& Grease, Coliform	At main canal headworks to establish baseline water quality for surface water entering main canal	Two times: once at beginning of construction period, and once at beginning of wet season irrigation period	PMIC and PMU
During Construction			
Dust and noise	Site inspection of all subproject sites	Quarterly	PMIC to supervise and PMU to inspect
Surface water quality: pH, SS, EC, NH_4+, NO_3- , $PO_{4\ 3}$-, DO, BOD5, COD, Oil& Grease, Coliform	Canal waters 100m downstream of major construction sites.	Quarterly	PMIC and PMU
Silt and dredge spoil: Organic matter, Zn, Cu, Pb, Hg, As, Cd moisture content, phenols, mineral oil,	Canal silt cleared from waterway. Three sampling locations - at start, midpoint and end of main canal (Taing Krasaing).	Once at each location to check disposal/reuse safety.	PMIC and PMU
Operation Phase			
Surface water quality: pH, SS, EC, NH_4+, NO_3- , $PO_{4\ 3}$-, DO,	Canal waters at start, midpoint and end of main canal.	Semi-annual	PDWRAM to contract an organization to do sampling and

[1] PRC: GB4284-84 Control standards for pollutants in sludge for agricultural use. PRC: GB/T23486-2009 Sludge quality for afforestation in gardens or forests. Japan: Environmental Quality Standards (EQS) for soil pollution, August 1991.

Parameters	Location	Frequency	Responsibility
BOD5, COD, Oil& Grease, Coliform			testing
Groundwater quality: "Priority Parameters": pH, Turbidity, Arsenic, Iron, TDS, Pesticides, coliforms.	• Five household wells located within each of the water user commune areas of the Taing Krasaing scheme • Five household wells located within each of the water user commune areas of the Prek Chik scheme	Semi-annual	PDWRAM to contract an organization to do sampling and testing

2. Monitoring Management

13. During construction, the PMU will make appropriate arrangements for monitoring according to the progress of implementation. Monitoring reports will be made available to MOE as required, on a quarterly basis during construction. When complaints are received from the public (either directly or via the formal grievance redress mechanism), PMU staff will conduct additional inspections immediately.

3. Monitoring Costs

14. The activities of the PMU' monitoring during construction and the initial operational period will be funded from the construction budget. The PDWRAMs' ongoing monitoring costs will be covered by their operational budget. A summary of monitoring costs is given in Table A.3.

Table A.3: Estimated Monitoring Costs ($)

Province	Subproject	Construction Stage			Operation Stage		Total
		Year 1	Year 2	Year 3	Year 4	Year 5	
Kampong Thum	Taing Krasaing	7,500	7,500	7,500	4,500	4,500	31,500
Battambang	Prek Chik	7,500	7,500	7,500	4,500	4,500	31,500

Table A.4: Total EMP Costs ($)

Scheme	Construction Environmental Management	Construction Environmental Monitoring (over 3 years)	Operational Environmental Management	Operational Environmental Monitoring (first 2 years)	EMP Training Costs	Totals
Taing Krasaing	124,100	22,500	18,250	9,000	32,850	206,700
Prek Chik	41,450	22,500	6,750	9,000	18,900	98,600
Totals	**165,550**	**45,000**	**25,000**	**18,000**	**51,750**	**305,300**

4. Environmental Monitoring Reports

15. To ensure proper and timely implementation of the EMP and adherence to the agreed environmental covenants, the PMU will submit semi-annual project progress reports to the ADB including environmental performance based on the monitoring and inspections data provided by the PMU. The PMIC will help the PMU to prepare the environment performance report, which will be disclosed on the ADB website.

5. Training Program

16. The training proposed in this EMP is in addition to the capacity building component within the Uplands Irrigation and Water Resources Management Sector Project design, which will target the strengthening of, and skills transfer to PDWRAMs and FWUCs. The training listed in the EMP (Table A1.1) is targeted at the PMU initially and later the construction contractors to enable them to implement environmental protection measures in construction; and to PDWRAMs to enable them to implement environmental protection measures in scheme operation.

17. The EMP training will be incorporated into the Project Training Plan when it is finalized.

APPENDIX 2: CLIMATE RISK AND VULNERABILITY ASSESSMENT

I. OVERVIEW

A. Background

1. This Climate Risk and Vulnerability Assessment is prepared and submitted as part of the due diligence under the Project Preparatory Technical Assistance (PPTA) for preparing the Uplands Irrigation and Water Resources Management Sector Project. This PPTA is based on agreement between ADB and the Royal Government of Cambodia (Government) and funding of the PPTA is under a grant from the ADB.

2. The overall goal of the Project is to assist the Government to improve the management and governance of existing irrigation systems, increase agricultural production, and improve the productivity of subproject areas with the aim to increase the incomes of poor farmers. The project will focus on increased efficiency of irrigation systems and improved management of water resources in the uplands areas away from the Tonle Sap.

B. Project Components

3. A long list of candidate subprojects was developed during the course of the PPTA, along with selection criteria for finalizing the preferred ones. These criteria identified the first two subprojects to be funded (called “core” subprojects). These are parts of the Taing Krasaing Scheme in Kampong Thum Province and the Prek Chik Scheme in Battambang Province (Figure A2.1).

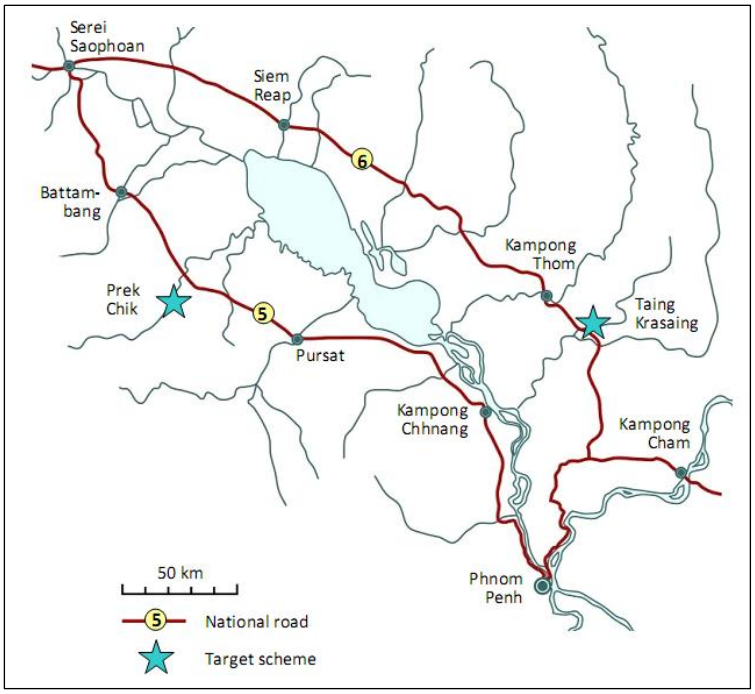


Figure A2.1: Location of Core Subprojects

4. The specifications of the proposed core subprojects in the Uplands Irrigation and Water Resources Management Sector Project comprise works to improve the headworks and

main canal of each. Secondary and tertiary canals, as well as extensions to the main canal (in the case of Taing Krasaing) have been included in the "long list" which are covered by the Project Environmental Assessment and Review Framework.

5. Irrigated agriculture in both Kampong Thom and Battambang provinces is wet season rice-based. If sufficient water is available, a second crop of either rice or vegetables and fruits such as pineapple and water melon is sown. During dry season, many lands are observed to be fallow. In general, lands are quite level. In the wet season, the schemes also have drainage problems during the wet season; and water-logged areas are observed in several places.

6. Systems, in general, show poor maintenance of their facilities. Many canals are subject to embankment erosion, especially in the sandy soils. Recently built systems were observed to be either still incomplete and under delayed construction or abandoned and not usable after just a few seasons. Several lined canal parts/systems were also observed as dry and not connected to a water supply.

7. Rice yields are low in general between 0.8 to 1.5 ton/ha. Seed quality is often poor. Most planting is broadcast, and requires both rain and some irrigation to meet the large needs of land soaking and land preparation.

1. Taing Krasaing Scheme

8. The Taing Krasaing system is located some 25 km south-east of the city of Kampong Thom, close to National Highway No.6, with Phnom Penh a 185 km drive away. The TK system is supplied by a simple reservoir with outlet-control gates on the Taing Krasaing River. The system was constructed during the period 1975–1978, underwent rehabilitation in 2000, and had partial sections improved and modernized in 2005 and 2012. The watershed upstream is estimated at some 1,100 km^2.

2. Prek Chik Scheme

9. Construction of the 28 km long Preuk Chik canal, linked to the Brassac Reservoir via the Stung Dauntry, was started during 1977. It was unfinished when construction work ceased in late 1978. After 1979, the partly finished canal was largely unused until some small repairs were made by the Battambang PDWRAM in 2003. Major rehabilitation work was done by MOWRAM in 2010 using funding from the Japanese government with the aim of bringing the PKC into effective operation. This construction work was completed at the beginning of 2012. The MOWRAM rehabilitation plan focused on the main canal and its irrigation structures.

3. Command Areas

10. Work on the two core subprojects will be on the main canals only. No extension of the main canal nor secondary or tertiary irrigation canals are included in the core subprojects. These will be part of later funding and implementation. However, the rehabilitation of the schemes starting with the refurbishment of the main canals and extending to later secondary and tertiary canals and their control structures will enable a greater area of irrigation to ultimately become available for cropping. The full irrigation command area must therefore be considered in assessing the sustainability of proposed water resource use under current circumstances and future impacts on sustainability due to climate change.

11. Table A2.1 shows the potential changes in the irrigated area when the subprojects,

including the secondary and tertiary canals, are complete.

Table A2.1: Increases in Irrigated Areas as a Result of the Project

	Taing Krasaing		Prek Chik	
	Before Project	After Project	Before Project	After Project
Irrigated Area (ha)	1,400	9,000	6,000	19,000

II. CLIMATE RISK SCREENING

A. Climatic and Hydrological Trends

12. The climates of the Battambang and Kampong Thum areas are characterized by distinct rainy and dry seasons. The southwest monsoon starts in May and lasts till October, while from November to April dry northeast weather patterns predominate.

13. For Battambang, the average annual rainfall ranges from 1200mm to 1300 mm, with peak rainfall occurring in September-October and the lowest rainfall in January. Temperature is lowest in December-January with an average minimum temperature of 26^{o}C and the highest in April with an average maximum of 34^{o}C. The wind direction during the rainy season is prevalent from south-west to north-east and from the south-west during the dry season.

14. For Kampong Thum, the rainfall is slightly higher, with average annual falls of 1300 mm, with peak rainfall occurring in September/October and the lowest rainfall in February. Temperature and wind patterns are similar to those of Battambang.

15. Total inflows to the Taing Krasaing system in Kampong Thum are shown in Figure A2.2 and Table A2.2 below. The yellow (m^3/s) and orange (MCM) highlighted figures in Table A2.2 show the very low dry season flows.

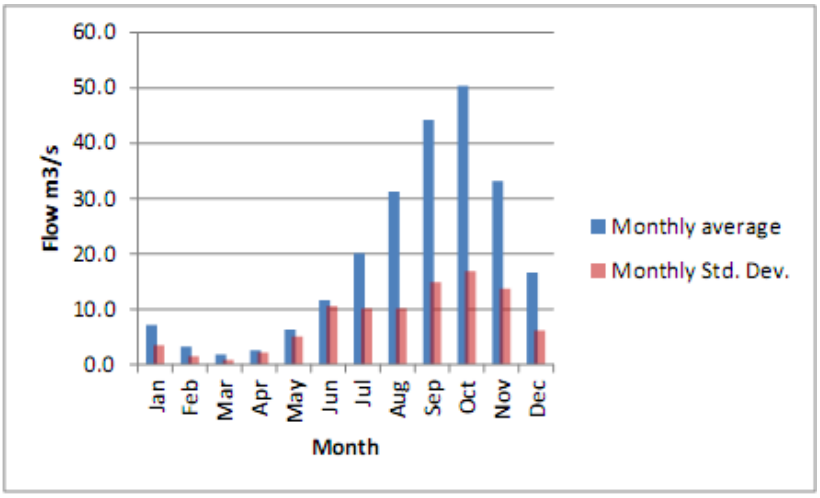


Figure A2.2: Taing Krasaing Monthly Average Inflows and Standard Deviation

Table A2.2: Total Taing Krasaing Inflows Monthly Average, Dry, Minimum and Maximum Flows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average. (m3/s)	7.1	3.2	1.8	2.6	6.3	11.6	20.2	31.3	44.2	50.4	33.2	16.6	19.1
Average (MCM)	19.1	7.8	4.9	6.7	16.9	30.2	54.0	83.8	114.6	135.0	86.1	44.6	603.5
Dry year (m3/s)	4.1	2.0	1.2	0.7	0.7	9.0	23.8	36.9	32.3	28.4	15.5	6.9	13.5
Dry year (MCM)	10.9	4.8	3.3	1.8	1.8	23.3	63.8	98.8	83.8	76.1	40.1	18.5	426.9
Max Year (m3/s)	16.2	7.1	3.3	9.2	16.8	53.1	41.5	52.3	76.2	87.9	74.9	32.8	28.4
Max Year (MCM)	43.4	17.2	8.8	23.8	44.9	137.7	111.2	140.0	197.5	235.4	194.2	88.0	900.1
Min Year (m3/s)	0.0	0.0	0.0	0.4	0.5	1.0	1.0	14.5	16.1	26.0	15.5	6.9	10.8
Min Year (MCM)	0.0	0.0	0.0	1.0	1.4	2.5	2.7	38.9	41.6	69.8	40.1	18.5	341.0

Note: The yellow (m^3/s) and orange (MCM) highlighted figures show the very low dry season flows.
Source: PPTA Consultant.

16. Total inflows to the Prek Chik system in Battambang are shown in Figure A2.3 and Table A2.3 below. The yellow (m^3/s) and orange (MCM) highlighted figures in Table A2.3 show the very low dry season flows.

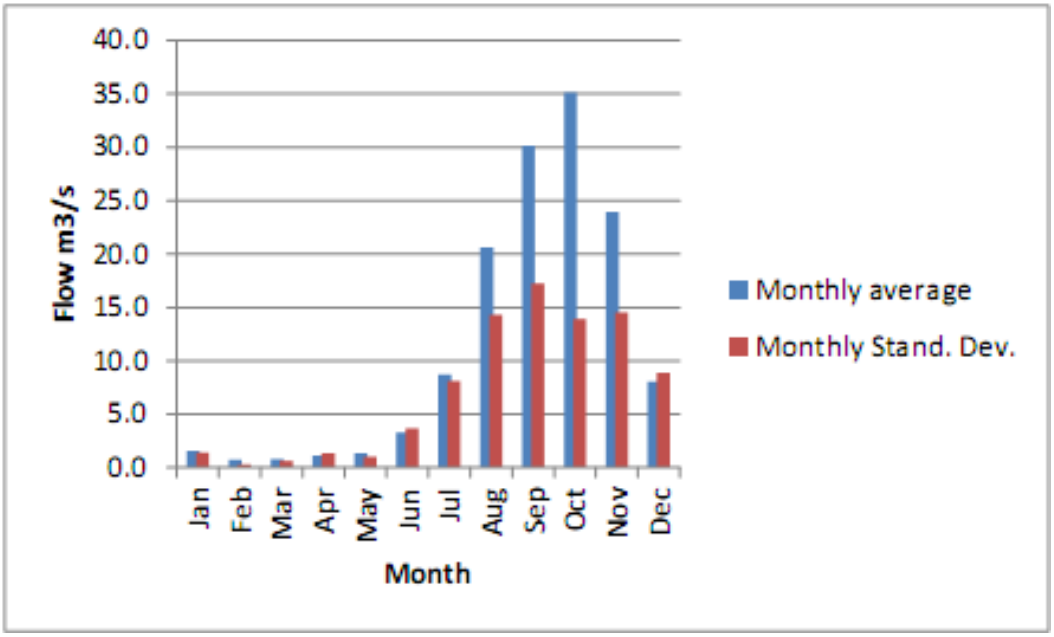


Figure A2.3: Prek Chik Monthly Average Inflows and Standard Deviation

Table A2.3: Total Prek Chik Inflows Monthly Average, Dry, Minimum and Maximum Flows

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average. (m3/s)	1.5	0.8	0.8	1.1	1.3	3.3	8.7	20.6	30.2	35.2	23.9	8.0	11.3
Average (MCM)	4.1	1.8	2.1	3.0	3.5	8.5	23.4	55.3	78.2	94.2	62.0	21.5	357.7
Dry year (m3/s)	0.6	0.4	0.3	1.0	0.9	2.4	6.2	29.7	29.2	10.7	14.7	2.9	8.3
Dry year (MCM)	1.7	0.9	0.8	2.7	2.3	6.2	16.7	79.5	75.8	28.7	38.2	7.7	261.1
Max Year (m3/s)	6.3	1.4	2.7	6.1	3.6	16.8	36.0	45.5	67.0	64.6	53.9	34.4	19.2
Max Year (MCM)	16.9	3.5	7.2	15.7	9.7	43.6	96.5	121.8	173.6	173.0	139.7	92.2	607.8
Min Year (m3/s)	0.6	0.4	0.3	0.2	0.2	0.5	0.6	1.6	5.3	10.7	5.6	0.9	3.7
Min Year (MCM)	1.7	0.9	0.8	0.5	0.6	1.3	1.7	4.4	13.8	28.7	14.4	2.5	118.2

Note: The yellow (m^3/s) and orange (MCM) highlighted figures show the very low dry season flows.
Source: PPTA Consultant.

B. Floods and Extreme Weather Events

17. Flooding is a regular phenomenon in Cambodia, with rainfalls commonly exceeding 500mm per month in the rainy season. However, recent flooding in the Mekong region has been very damaging and the Mekong River Commission records show an increasingly shorter return period for major floods.

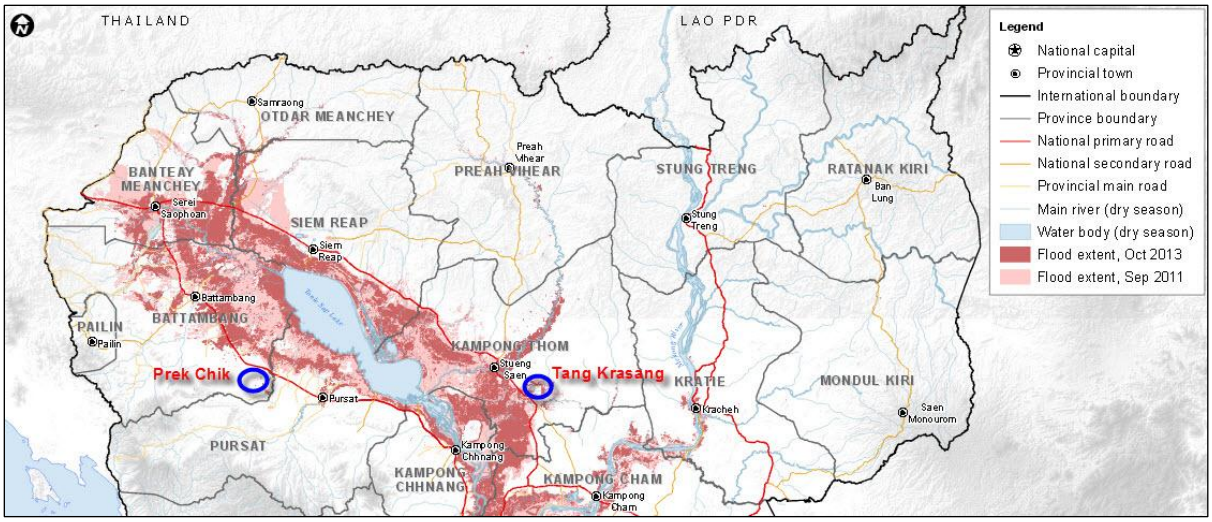
18. The table below compares data collected by NCDM in 2013 and 2011, at the peak of the floods in each year, by Province. Changes in the number of affected or evacuated families in 2013 compared to 2011, are highlighted.

Table A2.4: Affected and Evacuated Families in 2013 and 2011 (Kampong Thom and Battamabang)

Province	2013	2011	Comparison (affected families) 2013 and 2011	2013	2011	Comparison (Evacuated families), 2013 and 2011
	affected families	affected families		Evacuated families	Evacuated families	
Battambang	74,160	13,921	+60,239	4,504	1,194	+3,310
Kg. Thom	17,463	54,414	-36,951	1,114	2,448	-1,334

Source: Humanitarian Response Forum (HRF), Final Report No.07, December 2013

19. Data on flooding at the subproject sites is unavailable, but national mapping of the 2011 and 2013 floods (Figure A2.4) shows that the Taing Krasaing subproject was fully affected by these floods, and that the Prek Chik area was only marginally affected.



Source: World Food Programme Cambodia 2013

Figure A2.4: 2011 and 2013 Floods

C. Climate Screening

20. The potential for the project to be affected by future climate change was considered during the Rapid Environmental Assessment (REA) undertaken by the ADB SEER Division during project planning, using the *Checklist for Preliminary Climate Risk S*creening for irrigation projects (Annex A).

21. The screening identified drought and floods as the key risk areas affecting siting/design, maintenance and performance. Droughts were identified as affecting water availability and requiring irrigation planning and careful calculation of crop water needs as a response. Floods were identified as dangers to canal walls and structures, which will need to be designed to withstand them.

22. The screening checklist summarised the potential climate risks as follows.

Table A2.4: Potential Climate Risks

Location and Design of project	Affected sections of the canals will be strengthened to withstand anticipated floods and landslides and drainage facilities will be improved. For droughts irrigation scheduling will be done based on cropwater requirements and joint reservoir operation will be designed and adopted
Materials and Maintenance	Floods may affect the infrastructure if not designed to withstand those.
Performance of project outputs	Droughts may affect irrigation supplies

23. The overall score for potential climate risk was 3 (with no individual score of 2) and was assigned a medium risk category.

III. ASSESSING ADAPTATION NEEDS

24. The adaptation measures appropriate to the project are derived in a three step process namely: impact, vulnerability and adaptation analyses.

25. Impact assessments consider climate trends and climate predictions. The vulnerability assessment considers the degree to which the objectives of the irrigation subprojects could be adversely affected by climate change impacts. The assessment of adaptation in design and operation considers engineering and non-engineering solutions. Finally, the implementation of adaptation measures is described.

A. Impact Assessment

26. The result of modelling studies in the Initial National Communication (INC) and the Second National Communication (SNC) of the Cambodian National Climate Change Committee indicates that Cambodia's mean surface temperature has increased by 0.8°C since 1960, and that it will continue to increase at a rate of between 0.013°C and 0.036°C per year up to 2099. The rate of temperature increase will be higher in low altitude areas such as the subproject sites which are between 10 and 20 m ASL.

27. Under elevated CO_2 with low rate of emission scenarios (SRESB1),[1] it is likely that wet season rainfall will continue to increase in future, and then might decrease again after 2050. But under high emission scenarios (SRESA2), the direction of change will reverse.[2] The magnitudes of these changes are illustrated in the following graphs (Figure A2.5).

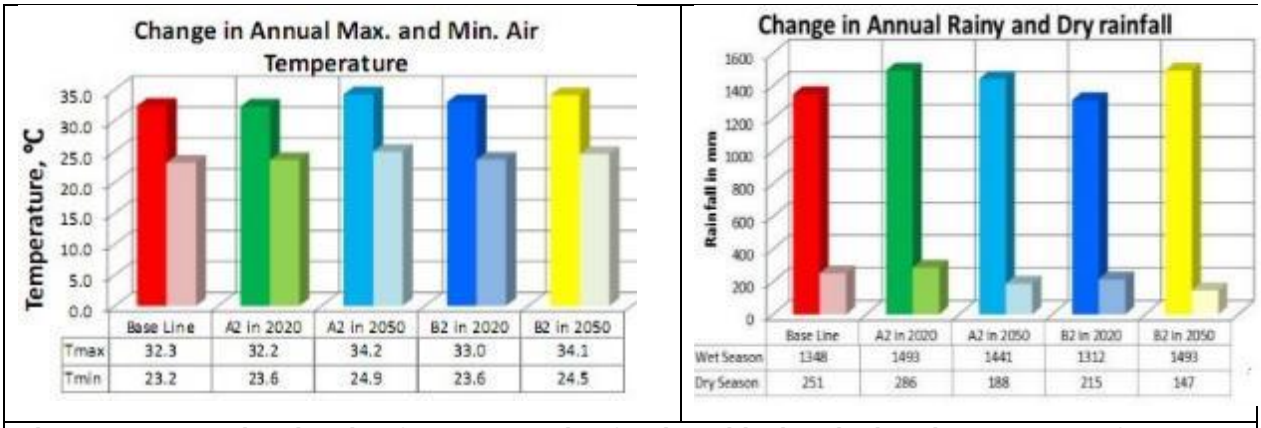


Figure A2.5: Graphs showing future scenarios for the critical agricultural parameters of temperature and rainfall. Scenarios are A2 (a more divided world) and B2 (a world more divided, but more ecologically friendly). Source: Sopharith, 2015

28. Climate change is expected to alter the current runoff and rainfall regimes. Climate change assessments for Cambodia indicate greater but more variable rainfall, increased crop

[1] IPCC's Special Report on Emission Scenarios (SRES) has four scenarios A1, A2, B1 and B2 describing differing emission rates and geopolitical settings. In summary; A is economics driven rather than environmental; B is more environmentally drive. 1 is countries operating in concert; 2 is countries pursuing their own aims.

[2] National Climate Change Committee 2013, Cambodia Climate Change Strategic Plan 2014-2023.

water demand, more frequent and severe floods, droughts and wind storms.[3]

29. Most of the increase in average annual rainfall predicted by models is expected to occur in the already wet months of the year, with only a minor or no increase over the dry season. The higher temperatures will increase crop water demands. These climate changes have the potential to influence both dry and wet season flow in the Project area.

30. The predicted changes in rainfall and temperature will combine to affect future irrigated water requirements (IWR). Figure III.2 below shows predicted IWR for all SRES projections for nation states acting in isolation (A2 and B2 scenarios).

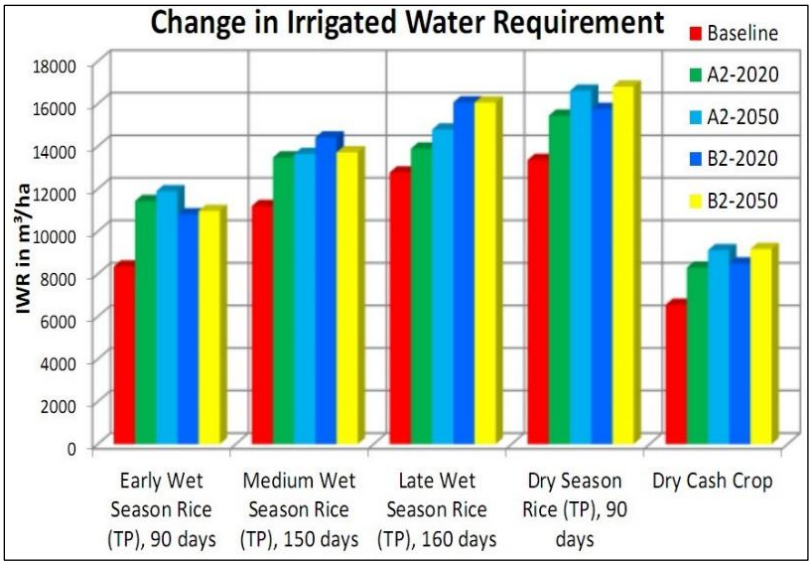


Figure A2.6: Irrigation water requirements from IPCC SRES. Source: Sopharith, 2015

B. Vulnerability Assessment

1. Crop Water Demand

31. The subprojects will increase existing levels of water extraction for irrigation. The impact of this on existing water resources has been examined through seasonal water balances for each of the two cropping alternatives applicable to the subproject schemes.

32. The assumptions for calculating seasonal water balances are based upon cropping calendars for upland irrigated rice in the subproject provinces derived from consultation with farmers. These show two main cropping schemes:

(i) **Cropping alternative I:** two short season (90 day) rice crops with the first in the first part of the wet season (May- Aug inclusive) followed by a second short season rice crop beginning in the last part of the wet season and extending into the early dry season (Sept-Dec incl.); and,

[3] Tes, S. Jan 2015. Assessment of Water Resources for Improved Water Governance under Climate Change: Stung Chinit River Catchment. Presentation to Third Steering Committee Meeting Climate Change and Water Governance in Cambodia 20 January 2015 , Cambodiana Hotel, Phnom Penh.

(ii) **Cropping alternative II:** a single medium season (130 days) rice crop spanning the main wet season (July-Nov inclusive).

33. The PPTA also calculated the water needs for the cropping alternatives at a range of irrigation efficiencies (including water requirements for pre-saturation of paddy and establishment of a water layer for planting).[4] All these calculations are presented in the core subprojects IEE.

34. The following seasonal water balances are based upon the inflow data for Taing Krasaing and Prek Chik calculated by the PPTA team with an irrigation efficiency of 40%. They compare seasonal water needs with water supply for the projected expansion of irrigation areas (total irrigated areas after the project of 9,000 ha for Taing Krasaing, and 19,000 ha for Prek Chik).

Table A2.5: Water Balance for a 9,000 ha Irrigation Area at Taing Krasaing

Taing Krasaing			
Wet Season`			
Year	**Crop**	**Water Need (MCM)**	**Water Available (MCM)**
Low rainfall year	2x Short season variety (May-Aug) 90 day+	135	188
	1x Medium season variety (July-Nov) 130 day+	144	473
Normal rainfall year	2x Short season variety (May-Aug) 90 day+	99	185
	1x Medium season variety (July-Nov) 130 day+	126	363
Dry Season			
Low rainfall year	1x Short season variety (Sept-Dec) 90 day+	162	277
Normal rainfall year	1x Short season variety (Sept-Dec) 90 day+	157.5	400

Table A2.6: Water Balance for a 19,000ha Irrigation Area at Prek Chik

Prek Chik			
Wet Season			
Year	**Crop**	**Water Need (MCM)**	**Water Available (MCM)**
Low rainfall year	2x Short season variety (May-Aug) 90 day+	285	105
	1x Medium season variety (July-Nov) 130 day+	304	239
Normal rainfall year	2x Short season variety (May-Aug) 90 day+	209	91
	1x Medium season variety (July-Nov) 130 day+	266	314
Dry Season			
Low rainfall year	1x Short season variety (Sept-Dec) 90 day+	342	150
Normal rainfall year	1x Short season variety (Sept-Dec) 90 day+	332.5	256

[4] PPTA Mid-Term Report, Appendix 4.

Note: 90 day+ and 130 day+ refers to the growing period plus land preparation.
Source: PPTA team.

35. The shaded cells in the water balance show where water availability is sufficient for irrigation needs. The balance for Taing Krasaing shows that all cropping alternatives are sustainable and that surplus water exists for cash crops in addition to rice. The surplus of available water also indicates that other beneficial users of the water, either at the reservoir or directly from the main canal will not be disadvantaged.

36. For Prek Chik however the water balance indicates that only a 130 day (medium) crop grown July-November in a normal rain year is sustainable over the projected irrigation area. If the command area was smaller, more cropping options would become possible for the available water. However, the results for Prek Chik indicate that water is a significantly limiting factor and any level of irrigation use will have the potential to impact on other beneficial water uses.

37. The surplus water available for the Taing Krasaing scheme shown by the water balance indicate a relatively low vulnerability to increased crop water demand. However, the limited water availability shown in the Prek Chik water balance indicates a significant vulnerability to increased crop water demand.

2. Flooding

38. The assessment of the condition and functionality of the schemes was undertaken by the PPTA team and the results are presented in as inventories DFR Appendix 2. The conditions which relate to floods are summarised as follows:

39. At Taing Krasaing, the headwork weir has severe erosion on the downstream side of the ogee crest. The damage has been caused by large magnitude flood flows over the weir. As water falls over the weir, creating shear stress on the rip-rap and inducing erosion. The foundations of the next weir immediately downstream have washed into the stilling pool. This structure is not performing its intended function to reduce sediment intake into the main canal. It should have a sill level lower than the sill of the main canal. Similarly, the present under-sluice is located too distant from the main canal and its crest is too high, even higher than the ogee crest.

40. Cross regulators in the upstream reach of the canal show serious damage from piping through side walls and beneath the structures. The design of the structures does not include a stilling basin to dissipate energy before water re-enters the earthen section of the channel. This problem has caused collapse in the stone pitching and the canal embankments downstream. A similar situation exists for the off-take structures and drainage inlets that are located along the canal.

41. At Prek Chik, there are several breaches in both side canal embankments and severe scouring downstream of some cross regulators. These problems are caused by high flows which result from the diversion of flood water from the river during wet season. Problems with the operation of the existing automatic flapped gate weir and the duck bill weir downstream of PKC intake caused flooding. The automatic flap gate weir and the duck bill weir have insufficient capacity to pass river floods. Because the canal has been used to reduce the impacts of the flood resulting in PKC flows exceeding its conveyance capacity.

42. There are insufficient cross drainage works at Prek Chik. Wet season paddy cultivation

on the southern side of the scheme is affected by flooding caused by the natural runoff from the southern mountain range and backing up by the right canal bank.

43. These findings indicate that there is a significant vulnerability in both schemes to increased flooding as a result of climate change.

C. Adaptation Assessment

44. The crops of interest for Taing Krasaing are early wet season rice and late wet/dry season rice (both 90 day crops). For Prek Chik the relevant crop is medium wet season rice. The projections show that IWR for these crops will be in the following ranges in 2020 and 2050:

Table A2.7: Predicted IWRs from Climate Change and IWRs Used in Subproject Water Balances

Crop	Predicted IWR in 2020 (m^3/ha)	Predicted IWR in 2050 (m^3/ha)	IWR used in Water Balances (Tables A2.5 and A2.6) for dry years (m^3/ha)
Early wet season rice	10,000-12,000	10,000-12,000	15,000
Late wet/dry season rice	15,000-16,000	16,000-17,000	18,000
Medium wet season rice	13,000-14,200	13,000-14,000	16,000

Source: PPTA Team

45. Table A2.7 shows that when the IWRs from future climate change scenarios are compared with the IWRs being used for subproject design the project design IWRs are consistently higher and already allow for the eventuality of future increased water demand in both 2020 and 2050.

46. Increases in rainfall are predicted in future scenarios for 2020 with a decrease to near present levels in 2050. Flooding events are expected to occur with greater frequency. The current poor condition of the structural elements at both Taing Krasaing and Prek Chik is largely due to their inability to cope with flood flows, compounded by low maintenance efforts. The redesign and refurbishment of the schemes offers many opportunities to correct this, and to provide robust structures for future flooding.

47. Additionally, the need to drain wet season flooding of cultivation areas will be highlighted in the short to medium term. The design of works to the main canals of the two core subprojects include refurbishment of all cross drainage structures (which drain flood water from farmland). The majority of these have been inoperative for many years and their restoration to working order will alleviate local flooding and predicted flooding.

D. Implementation

48. The Cambodia Climate Change Strategic Plan, 2014 – 2023 (CCCSP) identifies two strategic objectives to enhance adaptation to the impacts of future climate change. Strategic Objective 1 (Promote climate resilience through improving food, water and energy security) includes a provision to … *Rehabilitate and build water infrastructures including small-, medium- and large-scale irrigation schemes*. Strategic Objective 2 (Reduce sectoral, regional, gender vulnerability and health risks to climate change impacts) includes …. *Enhance the quality of rural infrastructure (roads, irrigation, wells and culverts) to be resilient to flood and drought*. The implementation of the core subprojects will be in line with these strategic objectives.

1. Project Response to Drought and Increased Crop Water Demand

49. The TA team has confirmed that the IWR calculations used in the subproject designs are consistently higher than the future increased water demand calculated for climate change scenarios for both 2020 and 2050. This means that IWRs from future climate change scenarios have already been incorporated in subproject designs. Table A2.8 shows the percentages by which design IWRs exceed predicted IWRs.

Table A2.8: Predicted IWRs from Climate Change and IWRs Used in Subproject Water Balances

Crop	Predicted IWR in 2020 (m^3/ha)	IWR used in subproject design are higher by …	Predicted IWR in 2050 (m^3/ha)	IWR used in subproject design are higher by …
Early wet season rice	10,000-12,000	25-50%	10,000-12,000	25-50%
Late wet/dry season rice	15,000-16,000	12.5-20%	16,000-17,000	6-12.5%
Medium wet season rice	13,000-14,200	12.5-23%	13,000-14,000	14-23%

50. The design IWRs for the subprojects already exceed the additional water requirements predicted for 2020 and 2050 by between 6% and 50%, so adaptation for this effect of climate change has been addressed.

51. Additionally, the PPTA team has also calculated irrigation efficiencies with and without the project for the Taing Krasaing and Prek Chik schemes. The total irrigation efficiency is shown in Table A2.9 below as $\mathbf{e_t}$.

52. This shows that the subproject designs will be increasing irrigation efficiency in the irrigation schemes significantly (from <5% to 40% in Taing Krasaing and from 15% to 40% in Prek Chik). These gains in irrigation efficiency will be important adaptation measures against future drought and higher water demand conditions caused by climate change.

Table A2.9: Irrigation Efficiencies for the Subprojects

Table on Irrigation Efficiencies					
	In Percent (%) All numbers estimates/approximates	**e_c**	**e_d**	**e_a**	**e_t**
1.a	Taing Krasaing – If operated as is (WITHOUT – Before)	<5	<5	<5	
1.b	Taing Krasaing –upon modernization (lining) WITH At start	(70)	(60)	(40)	17
1.c	Taing Krasaing – WITH after 5 years	(70)	(70)	(50)	25
1.d	Taing Krasaing – WITH after 10 years	(70)	(80)	(70)	40
	Compare to CAVAC Area south of Taing Krasaing and Chraob as is Today	(70)	80	70	40
2.a	Prek Chik – if operated as is – water supply restored	(60)	(60)	(40)	15
2.b	Prek Chik –upon modernization (no lining) WITH Project	(70)	(60)	(50)	25
2.c	Prek Chik – With after 5 years	(70)	(80)	(70)	40

e_c = conveyance efficiency; e_d = distribution efficiency; e_a = field application efficiency; e_t = total efficiency.
Source: DFR Volume 2, Appendix 4.

53. Non-structural adaptations to future drought and higher water demand conditions caused by climate change will be primarily addressed by operational procedures for the sustainable and responsible management of irrigation schemes. These will ensure that agreed irrigation and base flows are maintained and other beneficial water users are not disadvantaged. They will provide a clear and detailed extraction plans for the growing seasons. The plans will be prepared by the PMU in consultation with FWUCs, as a prerequisite for project commencement. This will be part of the larger Joint Reservoir Operations Plans (JOROP) which will be developed by the PMU and FWUCs in collaboration with the Project Management and Implementation Consultants (PMIC). Operational plans and operating practices for water allocations and drainage will be prepared by the PMU with support from PMIC and by involving FWUCs during implementation, and will be adopted by PDWRAM and FWUCs before completion of works on main canals.

2. Project Response to Increased Flood Potential

54. Currently floods overtop canal regulatory structures and canal walls on an indicated flood return period of 1 in 5 years. The PPTA team has calculated design flood levels and flows for structures along the main Taing Krasaing and Prek Chik canals.[5] These are shown in Tables A2.10 and A2.11.

Table A2.10: Design Flood Estimates for Taing Krasaing Subproject

	Taing Krasaing weir (1 in 100)	Taing Krasaing Canal siphon (1 in 50)	Stung Chinit weir (1 in 100)	Downstream Taing Krasaing weir (1 in 50)
Design flow (m^3/s)	494	6.2	1920	490

Table A2.11: Design Flood Estimates for Prek Chik Subproject

	Prek Chik offtake (1 in 50)	Prek Chik Canal siphon 1 (1 in 50)	Prek Chik Canal siphon 2 (1 in 100)
Design flow (m^3/s)	410	130	120

Source: PPTA Consultant

55. Design of structures for these significantly higher flood return periods have been incorporated in subproject planning. Canal walls will be reconstructed where needed and strengthened to withstand the above design flood flows and drainage facilities will be improved. Headworks spillways, sluice gates and weirs will be provided with erosion/scour protection to maintain the integrity of control structures against high energy flood flows. The crest height of control gates will be adjusted above the 1 in 100 year level to direct flood waters to control release sluices rather than overtopping and scouring.

56. Typical canal rehabilitation along high flow sections will involve replacement of structurally unsuitable material combined with an installed lining inside the canal slopes (Figure A2.7). This will retain a natural canal bed and benthic environment for the limited canal fisheries but protect side walls from flood scouring and failure.

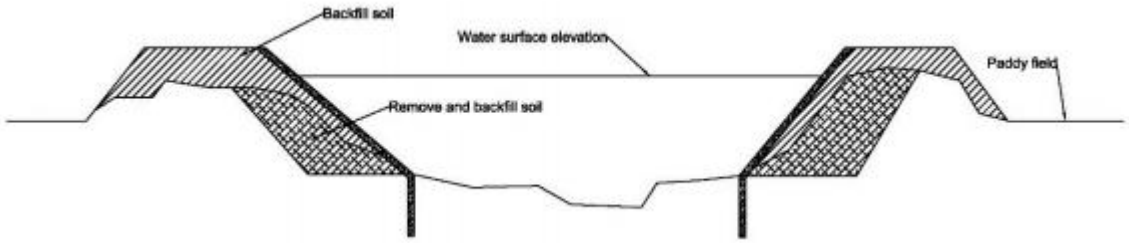


Figure A2.7: Typical canal rehabilitation incorporating side wall lining.

57. All cross regulators will be equipped with energy dissipation basins to ensure that excessive kinetic energy is dissipated before entering the earth channel section of the canals.

[5] The rainfall and flow data used for assessments of water availability is found in DFR Volume 2: Appendix 8.

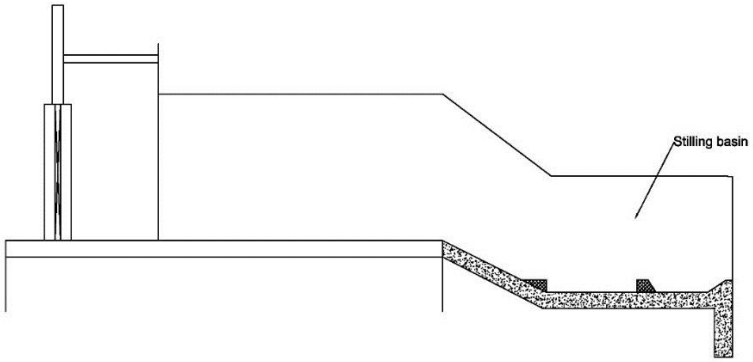


Figure A2.8: Downstream Erosion and Scour Protection of Cross Regulators on Main Canals

58. Cross-drainage of flood waters will be controlled by the construction of intercept drains on both sides of the main canals running parallel to the side canal embankments along their outside edges. The intercept drains will function to gather excess surface runoff from both sides of the canal and convey the accumulated water into the armoured invert syphon to discharge safely into the canal.

3. Watershed Management

59. Improved watershed management will act towards decreasing the flood potential and increasing the water availability of the irrigation schemes. Problems identified by the PPTA team were:

(i) Both the Taing Krasaing and the Prek Chik watersheds are in a state of degradation. There is a clear scope for rehabilitation across vegetation cover, topsoil management and surface drainage. The reservoirs in both core sites suffer from siltation, reportedly with increasing rates.
(ii) There are strong indications of the economic, social and environmental benefits of improved watershed management for land owners, concessionaires and water users.
(iii) The Taing Krasaing watershed is partly covered by land concessions, while there are no such concessions in the Prek Chik watershed.
(iv) Watershed Improvement of the watersheds require active participation (at the national and sub-national level) by MAFF and its Forestry Administration.

60. Many measures to directly improve the condition and performance of the watersheds supplying the irrigation schemes are outside the mandate of the project executing agency, MOWRAM. Corrective and preventative actions to improve watershed health have been considered by the PPTA and are discussed in the DFR Volume 2 Appendices. Actions common to the management of both subproject irrigation schemes include:

(i) Sediment control structures upstream of the supply reservoirs.
(ii) Discontinuation of irregular forest clearance and replacement with voluntarily reforestation and fruit tree plantation.
(iii) Re-development of idle lands (including reforestation and sustainable forest utilization).
(iv) The potential for risk management and damage control related to forest fires should be considered.

(v) Technological support and extension services in support of appropriate soil management.

61. Improvement of the Taing Krasaing watershed will also involve awareness-building and promotion of *'good practices',* supported by documentation of the achievable, tangible benefits. Upgrading the Prek Chik watershed will involve technical and financial support to community-based, sustainable forestry, re-activating the dormant forestry community and provision of technological and extension services support.

ANNEX A: Rapid Environmental Assessment (REA) Checklist

Instructions:

(i) The project team completes this checklist to support the environmental classification of a project. It is to be attached to the environmental categorization form and submitted to the Environment and Safeguards Division (RSES) for endorsement by the Director, RSES and for approval by the Chief Compliance Officer.

(ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.

(iii) Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country/Project Title: CAM (44328): Uplands Irrigation and Water Resources Management Sector Project

Sector Division: SFFR

Screening Questions	Yes	No	Remarks
A. PROJECT SITING IS THE PROJECT AREA ADJACENT TO OR WITHIN ANY OF THE FOLLOWING ENVIRONMENTALLY SENSITIVE AREAS?			
▪ PROTECTED AREA		☑	
▪ WETLAND		☑	
▪ MANGROVE		☑	
▪ ESTUARINE		☑	
▪ BUFFER ZONE OF PROTECTED AREA		☑	
▪ SPECIAL AREA FOR PROTECTING BIODIVERSITY		☑	
B. POTENTIAL ENVIRONMENTAL IMPACTS WILL THE PROJECT CAUSE…			
▪ loss of precious ecological values (e.g. result of encroachment into forests/swamplands or historical/cultural buildings/areas, disruption of hydrology of natural waterways, regional flooding, and drainage hazards)?		☑	Works are confined to rehabilitation/modernization within existing sites for irrigation infrastructure and will not encroach on new sites.
▪ conflicts in water supply rights and related social conflicts?		☑	Farmers water user communes will be organized and trained.

Screening Questions	Yes	No	Remarks
▪ impediments to movements of people and animals?	☑		Some disruption of movement of people and animals is expected during construction phase. Appropriate works scheduling and temporary access arrangements will be discussed and agreed with the communities during construction phase.
▪ potential ecological problems due to increased soil erosion and siltation, leading to decreased stream capacity?		☑	Not anticipated
▪ Insufficient drainage leading to salinity intrusion?		☑	Not anticipated
▪ over pumping of groundwater, leading to salinization and ground subsidence?		☑	No groundwater pumping, it's a surface irrigation project
▪ impairment of downstream water quality and therefore, impairment of downstream beneficial uses of water?		☑	No new construction is envisaged in the rivers, therefore downstream water quality is not going to be affected
▪ dislocation or involuntary resettlement of people?		☑	
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		☑	
▪ potential social conflicts arising from land tenure and land use issues?		☑	
▪ soil erosion before compaction and lining of canals?	☑		No major impact expected. Mitigation measures include: (i) diversion drains and bunds, and temporary silt traps/ponds; and (ii) stockpiling of soil in flat areas and far from drainage routes
▪ noise from construction equipment?	☑		Noise may be increased during construction phase. Discussions will be held with communities to agree on schedules and duration of noisy construction activities. All construction vehicles and equipment must be well maintained. Contractors must be licensed to carry out their work.
▪ dust during construction?	☑		Dust may be increased during construction phase but will be mitigated by appropriate management measures, such as (i) regular watering of exposed areas; (ii) covering all trucks carrying dispersible materials to and from the site; (iii) and agreement with the local community on the schedule and duration of construction works.
▪ waterlogging and soil salinization due to inadequate drainage and farm management?		☑	Not anticipated
▪ leaching of soil nutrients and changes in soil characteristics due to excessive application of irrigation water?		☑	Not anticipated

Screening Questions	Yes	No	Remarks
▪ reduction of downstream water supply during peak seasons?		☑	Irrigation efficiency will be increased so water flow regimes will not be affected.
▪ soil pollution, polluted farm runoff and groundwater, and public health risks due to excessive application of fertilizers and pesticides?		☑	
▪ soil erosion (furrow, surface)?		☑	
▪ scouring of canals?		☑	
▪ clogging of canals by sediments?			One of the activities in rehabilitation will be removal of sediment and clogging of canals. System design will be in place to avoid clogging by sediments. Where unavoidable, adequate operation and maintenance will be designed.
▪ clogging of canals by weeds?		☑	Not anticipated
▪ seawater intrusion into downstream freshwater systems?		☑	
▪ introduction of increase in incidence of waterborne or water related diseases?		☑	
▪ dangers to a safe and healthy working environment due to physical, chemical and biological hazards during project construction and operation?		☑	Occupational health and safety issues will not be significant. These will be managed through EMPs per subproject and environmental clauses in the construction contract.
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		☑	Local labor is to be recruited as much as possible.
▪ social conflicts if workers from other regions or countries are hired?		☑	
▪ risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?		☑	Rehabilitation work is unlikely to result in significant risks. Specific provision in the bidding documents and contracts together with monitoring of EMP implementation will be ensure minimizing such risks.
▪ community safety risks due to both accidental and natural hazards, especially where the structural elements or components of the project (e.g., irrigation dams) are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?		☑	Rehabilitation work is unlikely to result in significant risks. Specific provision in the bidding documents and contracts together with monitoring of EMP implementation will be ensure minimizing such risks.

A Checklist for Preliminary Climate Risk Screening

Country/Project Title: **CAM (44328): Uplands Irrigation and Water Resources Management Sector Project**

Sector : **Agriculture, natural resources and rural development**

Subsector: **Irrigation, Water-based natural resources management**

Division/Department: **SEER/SERD**

Screening Questions		**Score**	**Remarks**[17]
Location and Design of project	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	1	Affected sections of the canals will be strengthened to withstand anticipated floods and landslides. For droughts irrigation scheduling will be done based cropwater requirements
	Would the project design (e.g. the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc)?	0	Hydrological analysis will be done to forecast the river flows , water availability and extreme floods/droughts
Materials and Maintenance	Would weather, current and likely future climate conditions (e.g. prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g. construction material)?	0	

[17] If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.

	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s) ?	1	Floods may affect the infrastructure if not designed to withstand those.
Performance of project outputs	Would weather/climate conditions, and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g. hydro-power generation facilities) throughout their design life time?	1	Droughts may affect irrigation supplies

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response will be categorized as high risk project.

Result of Initial Screening (Low, Medium, High): Medium

Other Comments:_____
_____

Prepared by: _____