





# PREVENTION OF SALT WATER INGRESS THROUGH RIVER CHANNELS

Investment ID: 3.3

## INTRODUCTION



Deliverables	<ul style="list-style-type: none"><li>• Embankment</li><li>• Water gate with one-way valves</li></ul>
Beneficiaries	3,500
Budget	US\$ 185,000
Location	Protects Angkaol and Pong Teuk Communes

***Problem statement***

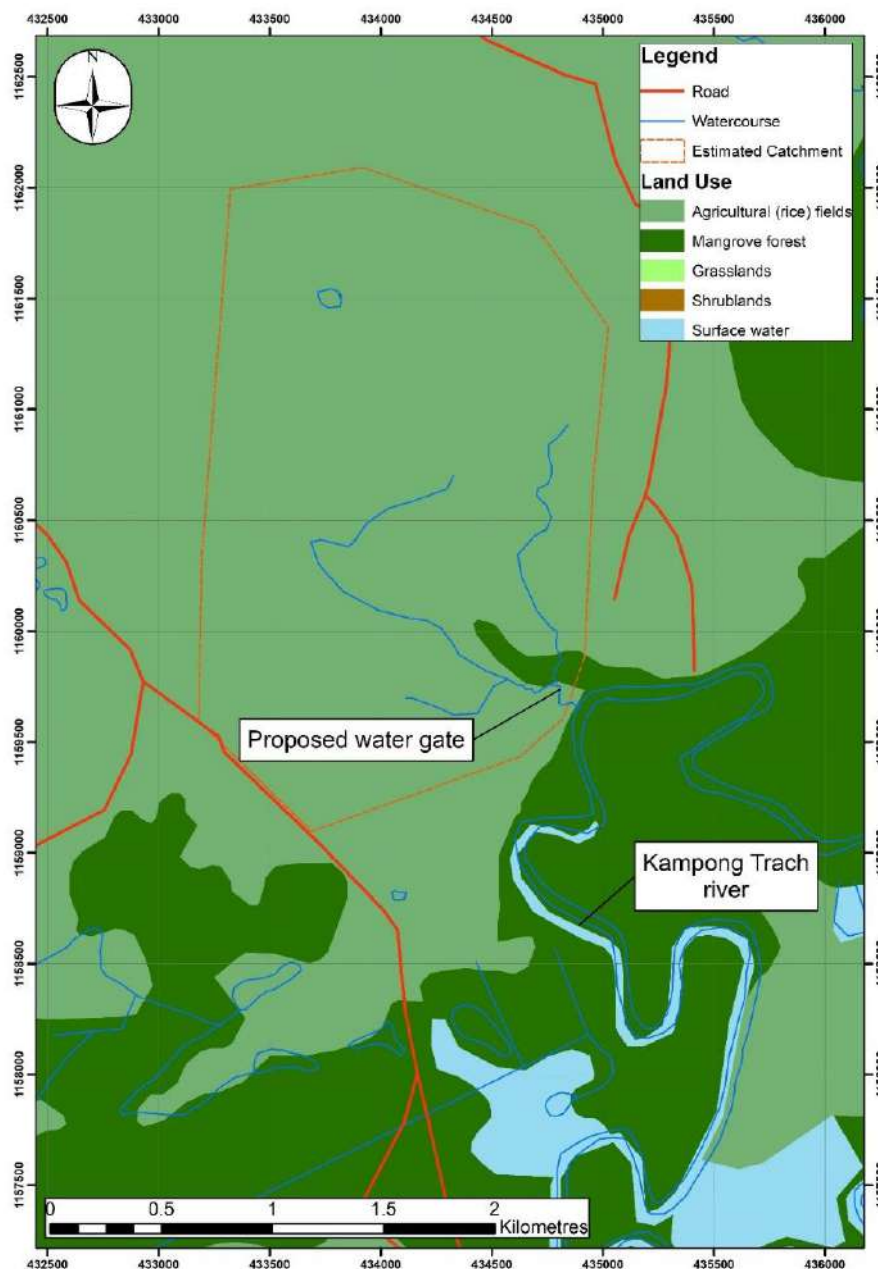
Communities relying on agriculture, (in Cambodia largely rice production), living near to the sea and on low-lying land, are at risk of saline intrusion from the sea and tidal rivers washing inland and causing salinization of their crops in extreme tidal events. This is exacerbated by the seasonal nature of Cambodia's climate, where for six months in the dry season there is very little runoff from the land.

Consultation and site investigations have indicated that, while some areas now have a tidal flooding embankment, others are still exposed to flooding from the open sea, which not only affects crop production but reduces the fertility of the soil for future cropping.

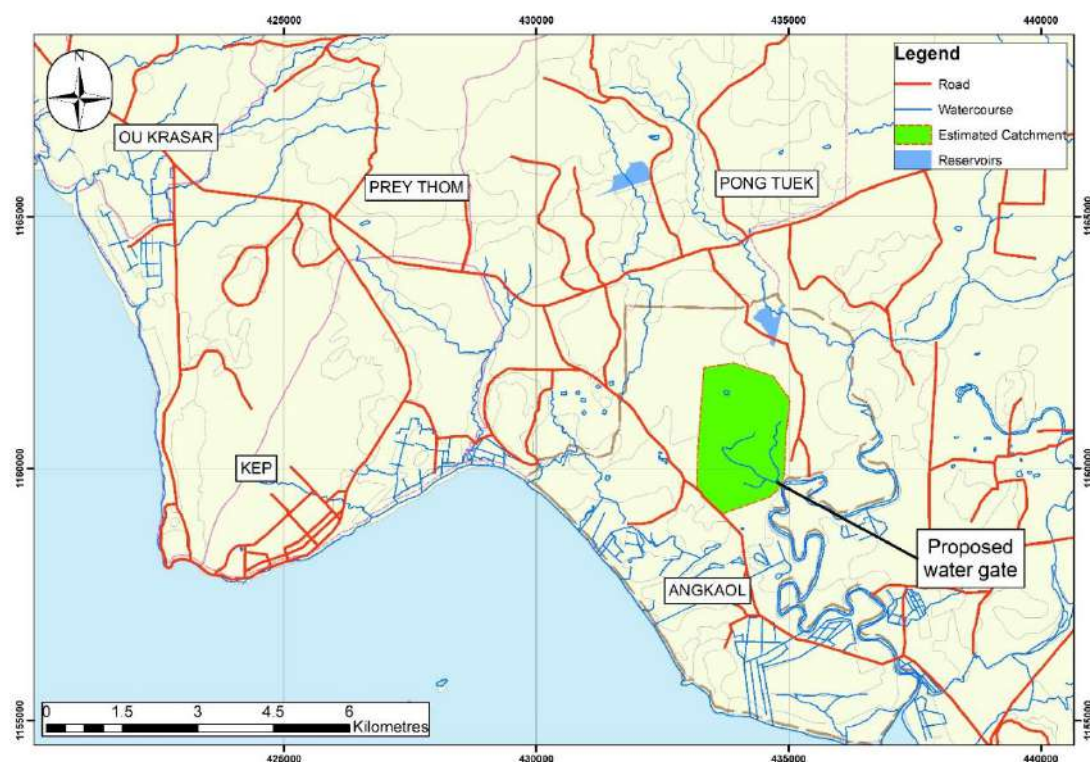
Any structure preventing inland flow of salt water must also allow outflow of surface flood waters during the rainy season, so a gate or sluice with a one-way non-return valve is necessary to enable the outflow.

## Location

A flood embankment has been proposed across an un-named tributary of the Kampong Trach river in Angkaol Commune. The location is shown on the maps below.



**Figure 1** “Map 1 – Location of proposed water gate on a tributary of the Kampong Trach tidal river”



**Figure 2** “Map 2 – Larger-scale map showing location in context of Kep Province”

### Beneficiaries

Angkaol Commune has benefitted in recent years from a new flood embankment protecting the commune and the adjacent inland commune of Pong Teuk from flooding directly from the sea. However, tidal flooding from the Kampong Trach Estuary is still a reality and this directly affects farms across a 4.5 km<sup>2</sup> area. There are 19,553 people currently reported as living in Angkaol and Pong Teuk Communes, with approximately 3,500 living within and wholly reliant on the area protected. If the risk of salinization is removed the entire community and the surrounding district will benefit from increased crop yields and improved soil structure.



## BUDGET

### *Embankment and Water Gate*

These costings are based on cost estimates for the National Road no. 3 upgrade works in 2012 adjusted for inflation and on a quote from the Phnom Penh Precast concrete company for the culverts and transport.

DESCRIPTION	QUANTITY	UNIT PRICE	COST
Topographic survey along proposed line of embankment, 370 m – (2 x skilled surveyor for 4 days each)	8	\$ 300	\$ 2,400
Site clearance	3.000 m2	\$ 20	\$ 60,000
Embankment fill	5,500 m3	\$ 0	\$ 0
Water gate - culverts	6	\$ 900	\$ 5,400
Water gate – transport for culverts	1	\$ 1,000	\$ 1,000
Water gate – concrete	160 m3	\$ 145	\$ 23,200
Water gate - steelwork	Lump Sum		\$ 15,000
Water gate – duck bill valves	4	\$ 400	\$ 1,600
Water gate – other (mesh etc.)			\$ 2,000
Temporary access track			\$ 10,000
Labour – skilled (3 labourers for 8 weeks)	120 days	\$ 30	\$ 3,600
Labour – unskilled (18 labourers for 8 weeks)	720 days	\$ 15	\$ 10,800
TOTAL			\$ 185,000

## DATA COLLECTION

### *Inputs*

This study has been informed by data provided by the Ministry of the Environment, Kep Provincial Department of Water Resources and Meteorology, Preah Sihanouk Provincial Department of Water Resources and Meteorology, Kep Provincial Department of the Environment and Angkaol Commune. Data for cost estimates has been provided by Arcadis and the Phnom Penh Precast concrete company. Mapping has used Google Earth satellite imagery and openly available GIS data including geology, land use and watercourses.

### *Consultations*

Consultation has been carried out with the National Ministry of the Environment, Kep Provincial Department of Water Resources and Meteorology, Kep Provincial Department of the Environment and Angkaol and Pong Teuk Communes.

Further information on consultations undertaken in the formulation of the proposal can be found in Part II, Section H.

### *Site Records*

A site visit took place and identified a location where an existing footpath crosses a stream on a wooden bridge (see Map 1 and cover picture). Either side of this bridge there is an elevated path which can be used as the foundation for a higher embankment. The path delineates the boundary between mangrove downstream (which requires a saline environment) and rice fields upstream (which require a fresh water environment). See Photos 1 and 2 in the Photos section below. It is proposed to create a more formal boundary with a flood embankment and water gate at this location (see maps 1 and 2 for location details).

## IMPLEMENTATION

### *Design*

The design comprises two elements, an embankment and a water gate.

The flood embankment is 370m long. This has been checked using GIS mapping and confirmed by the community but a full topographic survey along the line of the embankment is necessary to confirm the required length of the embankment before works are commenced. Upon completion of construction the crest level should be surveyed throughout to ensure a consistent flood defence level.

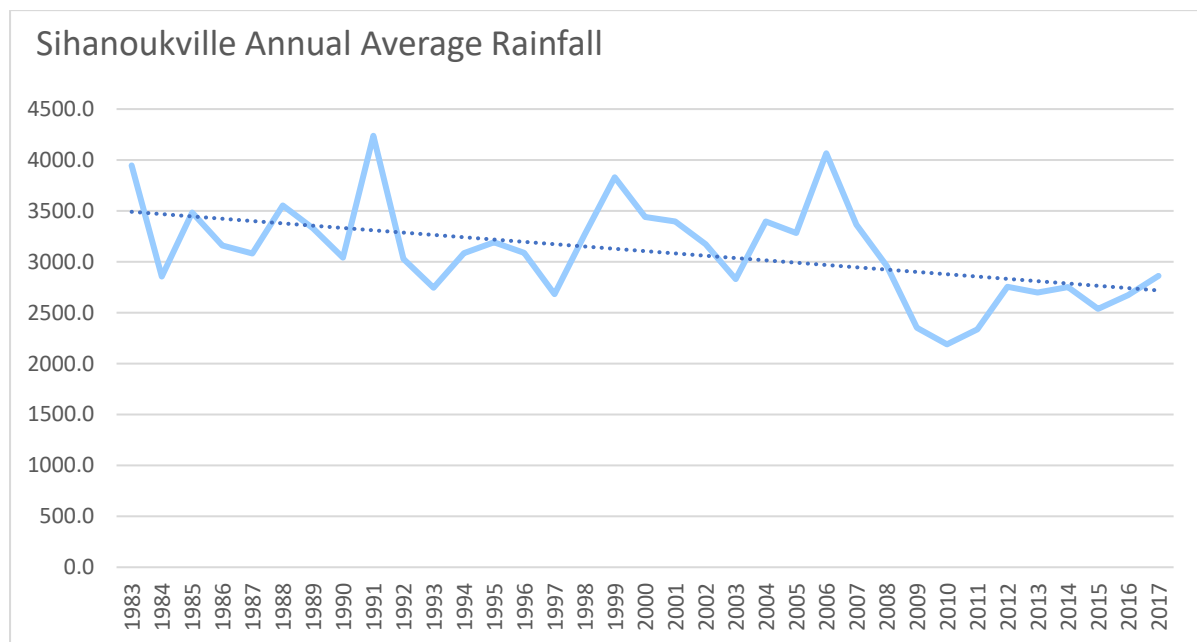
The embankment should be sufficient to prevent overtopping from the sea in extreme events up to 2100, in accordance with worst-case scenario projections of 1-metre sea level rise. In the Shoreline Assessment carried out for the Ministry of the Environment in 2014 it was estimated that an average sea level rise of 0.8m could occur by 2100. The community advised that the existing footpath is overtopped by up to 0.5m on extreme tides every 2-3 years. Therefore the new flood embankment will need to be a minimum of 1.3m above the existing footpath level, providing continued functionality under worst-case scenarios of future climate change. We have allowed a further 200mm freeboard in the estimations for this work.

It is proposed to construct a flood embankment 1.5m in height above the existing path, grading out to higher ground level on each side of the stream. The embankment should be a minimum of 2m in width at the crest and have 1 in 3 side slopes. The embankment is not required to withstand high tidal water levels for long periods and so compacted local alluvial soil with sufficient clay content to provide cohesion will be appropriate. The cross-section sketch (Drawing 1 in the Drawings section below) indicates the highest part of the embankment near to the water gate. The fill required to raise the embankment may be less as the ground rises to either side, but this can only be confirmed by the topographic survey. For the purposes of costing we have assumed that an average 1.85m depth of fill is required along the 370m length. Therefore the average cross-section of the extra embankment fill is 1.85m height x 8m width, giving a total fill requirement of 5,500m<sup>3</sup>.

It should be noted that the embankment fill will be sourced from the excavation works at the nearby O Thmar reservoir (See investment 3.4a). This is an alteration to the original proposal, based on comments from the Adaptation Fund. Recycled material from O Thmar will substantially reduce the cost of this intervention, and reduces the overall environmental and social safeguard risks of the project by reducing the amount of material that needs to be disposed of.



The water gate will be located where the embankment meets the stream, on the approximate alignment of the existing wooden bridge, and is required to pass a peak flood flow off the inland catchment to avoid drowning the rice fields and causing property flooding. No rainfall intensity data is available, but records of monthly total rainfall covering the period January 1983 to December 2017 as recorded in Sihanoukville 100km to the west of Angkaol are available, and have been used to estimate rainfall intensity. It is worth noting that the maximum monthly rainfall value was recorded in July 1991, and although the trend in average rainfall is increasing for the dry season months of January to March during the 34-year period of data collection, the trend for the rest of the year, including the wet season, is in steep decline with average monthly rainfall overall down by nearly 25% over this period (see graph below). Therefore it is likely that the peak runoff rate calculated here will not be exceeded.



The calculation is as follows:

Maximum rainfall per month = 1,319.7 mm = 1.3197 m = 0.043 m/day

Assume rain actually fell only 15% of the time, in intense bursts rather than continuously.  
This gives a peak rainfall rate of:

0.043 m/day divided by 15% = 0.284 m/day = 11.83 mm/hr

Using the Rational Method hydrology calculation, the Time of Concentration is:

$$T_c = (0.87 L^3/H)^{0.385}$$

Where L = length of catchment – 2.7 km

$H$  = difference in ground level across catchment = 2 m

Therefore  $T_c = 2.29$  hrs

The maximum flow to be discharged is given by:

$$Q = 0.278 C i A$$

Where  $C$  = Runoff coefficient (= 0.4)

$i$  = Rainfall intensity (= the peak rainfall rate x the time of concentration) = 27 mm/hr

$A$  = catchment area = 4.47 km<sup>2</sup>

Therefore, the maximum runoff at the proposed water gate location is 13.44 m<sup>3</sup>/s

A single 1m diameter concrete pipe culvert will pass approximately 2.4 m<sup>3</sup>/s flow so six 1m diameter culverts placed in parallel will address this volume of flow. It is proposed that four of these will be simple culverts with one-way valves to allow fresh water flows out but retain sufficient upstream water for cultivation, and prevent salt water ingress. The other two, in the deepest part of the channel (this is assumed to be the centre but this should be checked before construction starts) would be fitted with conventional sluice gates so these can be opened to allow flood flows to be passed through the structure in extreme conditions, but they should then be closed to prevent salt water from flowing into the rice fields once the flooding has passed.

An indicative sketch design is shown as Drawing 2 in the Drawings section below.

The gate structure including wing walls and head walls should be cast in concrete around the six pipes and the valves fitted to the seaward side of the structure. The vertical sluice gates fitted on the landward side can be of the same standard design as used elsewhere in Angkaol (see Photo 3 in the Photos section below).

It is proposed to use 'duck-bill' type non-return valves instead of the more conventional vertically-hung steel flap valves (see Photo 4 in the Photos section below). Flap valves are liable to failure through siltation and debris clogging them up, thereby preventing either opening or closure.

To provide further protection against failure from debris, given the likelihood of solid plastic waste being flushed down the stream in a flood, it is recommended that a galvanised wire 60mm x 60mm mesh debris screen is attached to the upstream side of the gate structure to cover over the culverts which have duck-bill valves on them.

## *Community Engagement*

The community have been consulted on a number of occasions and we were advised that previous studies into the construction of a flood defence here have been carried out. The works should proceed with the full engagement of the community, using local labour and materials where possible, and minimising disruption to the adjacent farming communities. Further consultation should take place prior to implementation to resolve any local concerns and address short-term disruption issues.

## *Construction*

In order to bring in construction components (e.g. culvert pipes and steelwork) and machinery to the site, a temporary roadway will need to be constructed. This will need to be designed and constructed to minimise disruption to the local community using state land as far as possible. The road should be removed on completion of the project.

## *Contractor Requirements*

The contractor must ensure that construction work minimises disruption to the local community. Local labour should be used as far as possible.

## *Key Risks & Safeguarding Issues*

### § Environmental

The works will require heavy components and machinery to be brought to site, and there is currently no suitable road for large vehicles to access to within 1km. Therefore a temporary tracky will need to be installed to enable access. There is a risk of environmental impact if the temporary track is not satisfactorily constructed and safely removed again after the completion of the works.

The works adjoin mangrove forest and it will be necessary to widen the footprint of the existing path separating the mangrove from the agricultural land. Care should be taken to minimise the impact on the mangrove.

### § Social Safeguards

There is a risk of conflict between the workforce employed on the construction and the local community. The community have been proactive in requesting the work to be done and where possible a local workforce should be employed to minimise any risk.

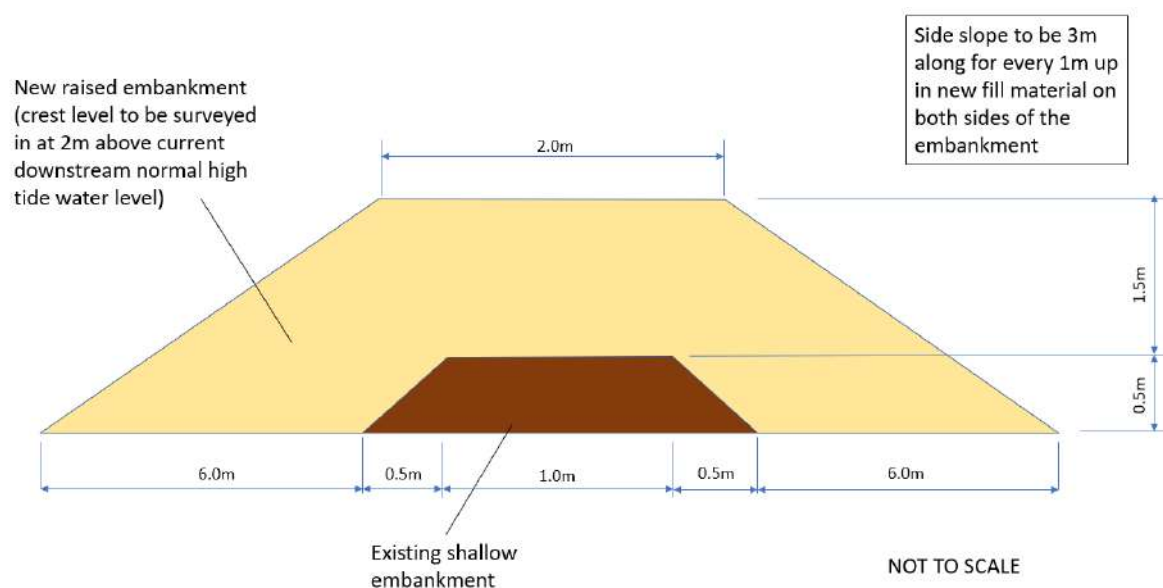
### § Gender/Youth (if applicable)



No safeguarding issues identified

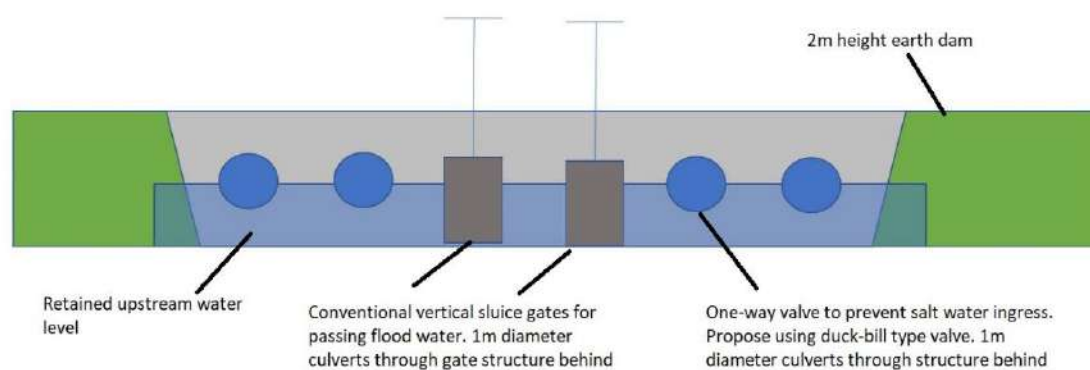
For more information on the Environmental and Social Safeguards in the project, please see Part II, Section K of the proposal.

## TECHNICAL DRAWINGS



**Figure 3**

*“Drawing 1 – proposed embankment indicative cross-section. The existing embankment is a shallow raised path between the salt water mangrove to the seaward and fresh water rice fields to landward. It is on average less than 0.5m above the upstream water level or downstream normal high tide water level.”*



**Figure 4**

*“Drawing 2 – indicative cross-section of gate structure. Automatic one-way valves to be on seaward side, manually-operated sluice gates to be on landward side. A mesh trash screen is to be installed across the upstream side to prevent solid plastic waste becoming stuck in the outfall culverts. The structure is approximately 18m wide with 6 x 1m diameter culverts passing through it.”*

## PHOTOS



**Figure 5**      *"Photo 1 - Path through rice fields near the proposed water gate. Fields irrigated with fresh water."*



**Figure 6**      *"Photo 2 – Mature mangrove forest growing in salt water."*



**Figure 7**      *“Photo 3 – typical sluice gate as used elsewhere in Angkaol – use same standard design for the vertical lifting gates in this sub-project.”*





*Figure 8      "Photo 4 – example of duck-bill outfall one-way valve."*

Table 1

ENVIRONMENTAL AND SOCIAL SAFEGUARD PRINCIPLE	RISK MITIGATION ACTIONS INCORPORATED IN THE DESIGN
<p><b><i>Compliance with the law</i></b></p> <p>projects/programmes supported by the Fund shall be in compliance with all applicable domestic and international law.</p>	<p>There are no anticipated legal issues with the intervention, which has been checked and is in full compliance with the law. For further information, please see the full proposal, Part II, Section E.</p>
<p><b><i>Access and Equity</i></b></p> <p>Projects/programmes supported by the Fund shall provide fair and equitable access to benefits in a manner that is inclusive and does not impede access to basic health services, clean water and sanitation, energy, education, housing, safe and decent working conditions, and land rights. Projects/programmes should not exacerbate existing inequities, particularly with respect to marginalized or vulnerable groups.</p>	<p>The Investment will deliver improved access to fresh water for poor farming communities, which will improve their capacity to grow crops for domestic use and sale, as well as increasing access to water for domestic use. Those benefitting most will be the furthest downstream, who are currently the most affected by upstream abstraction, therefore the sub-project will not exacerbate existing inequities, but will be likely to reduce them.</p>
<p><b><i>Marginalised and Vulnerable Groups</i></b></p> <p>Projects/programmes supported by the Fund shall avoid imposing any disproportionate adverse impacts on marginalized and vulnerable groups including children, women and girls, the elderly, indigenous people, tribal groups, displaced people, refugees, people living with disabilities, and people living with HIV/AIDS. In screening any proposed project/programme, the implementing entities shall assess and consider particular impacts on marginalized and vulnerable groups.</p>	<p>There are no anticipated issues regarding marginalised groups. The project will not prejudice the ability of any group or individual to access water – it will enhance it.</p>
<p><b><i>Human Rights</i></b></p> <p>Projects/programmes supported by the Fund shall respect and where applicable promote international human rights.</p>	<p>There is no evidence that human rights will be negatively affected. The investment will increase access to fresh water. Other human rights issues are detailed in the relevant sections below.</p>



***Gender Equity and Women's Empowerment***

Projects/programmes supported by the Fund shall be designed and implemented in such a way that both women and men 1) have equal opportunities to participate as per the Fund gender policy; 2) receive comparable social and economic benefits; and 3) do not suffer disproportionate adverse effects during the development process.

In the communities affected by the proposal it was observed that women tend to take more of a household and community management role and therefore they are likely to benefit further from the community's improved crop yield, as they will be likely to take on the role of selling surplus crops.

Men and women will be given equal opportunity to provide their labour to the construction process, under the [People's Process](#) approach. Whenever women provide their labour, the project will ensure that they have access to separate bathrooms and hygienic products.

All labourers (male and female) employed under the project will be given a mandatory briefing on the prevention of sexual harassment and exploitation prior to commencing their work.

***Core Labour Rights***

Projects/programmes supported by the Fund shall meet the core labour standards as identified by the International Labour Organization.

Safety equipment will be required for workers on the site and provided for them.

This activity will draw upon unskilled labour from the community. All workers in the project will be informed of their rights to organise, including joining formal labour unions, in accordance with the law. Unskilled labourers will be paid \$300 per month (assuming an 8-hour working day, 5 days per week, this is 50% higher than the national minimum wage).

All workers employed by the project (including under agreement of cooperation) will be aged 18 or over)

See above provisions for women's labour.

**Indigenous People**

The Fund shall not support projects/programmes that are inconsistent with the rights and responsibilities set forth in the UN Declaration on the Rights of Indigenous Peoples and other applicable international instruments relating to indigenous peoples..

There is no evidence of indigenous people or undocumented migrants living in the investment's target area

**Involuntary Resettlement**

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids or minimizes the need for involuntary resettlement. When limited involuntary resettlement is unavoidable, due process should be observed so that displaced persons shall be informed of their rights, consulted on their options, and offered technically, economically, and socially feasible resettlement alternatives or fair and adequate compensation.

There is no resettlement required as a result of this investment. The investment will take place on public land and the track to access the site will be constructed on public land where no one is currently living or using for agriculture

**Protection of Natural Habitat**

The Fund shall not support projects/programmes that would involve unjustified conversion or degradation of critical natural habitats, including those that are (a) legally protected; (b) officially proposed for protection; (c) recognized by authoritative sources for their high conservation value, including as critical habitat; or (d) recognized as protected by traditional or indigenous local communities.

This investment will define the boundary between salt water mangrove and cultivated rice paddies. As such it will help to prevent further erosion of the mangrove forest. The presence of a dam and water gate across the river will also form a barrier to downstream flow of solid waste entrained in the river, which could then be removed more easily rather than flushing out to sea. In this sense, the project provides two positive benefits to the natural habitat; 1) the defence and protection of mangroves, and 2) the protection of the ocean against solid waste. Construction of the temporary road access to site may cause a localised and temporary environmental impact. Care should be taken to keep this disruption to a minimum and the road should be removed and ground restored following construction.

***Conservation of Biological Diversity***

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids any significant or unjustified reduction or loss of biological diversity or the introduction of known invasive species.

Material used as fill will be sourced from O Thmar, about 2km away, so it will not contaminate the area with invasive species.

***Climate Change***

Projects/programmes supported by the Fund shall not result in any significant or unjustified increase in greenhouse gas emissions or other drivers of climate change.

The sub-project will help to adapt to the effects of climate change for the poor local communities. There will be necessary but controlled CO<sub>2</sub> emissions associated with the construction period only (particularly from transportation).

***Pollution Prevention and Resource Efficiency***

Projects/programmes supported by the Fund shall be designed and implemented in a way that meets applicable international standards for maximizing energy efficiency and minimizing material resource use, the production of wastes, and the release of pollutants.

Environmental safeguards should be applied during the construction works to ensure no cement or oils are allowed into the environment. The embankment fill material to be used in the investment will be 5,500m<sup>3</sup> of material excavated from O Thmar reservoir. This will enhance resource efficiency of the overall project and reduce the amount of waste generated

***Public Health***

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids potentially significant negative impacts on public health.

The sub-project should benefit public health by improving crop production. There are no anticipated negative effects – the construction does not use any hazardous materials.

***Physical and Cultural Heritage***

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids the alteration, damage, or removal of any physical cultural resources, cultural sites, and sites with unique natural values recognized as such at the community, national or international level. Projects/programmes should also not permanently interfere with existing access and use of such physical and cultural resources.

There is no evidence of any areas of cultural interest or sites of physical or intangible heritage on or around the site of the construction.

***Land and Soil Conservation***

Projects/programmes supported by the Fund shall be designed and implemented in a way that promotes soil conservation and avoids degradation or conversion of productive lands or land that provides valuable ecosystem services.

The investment should reduce the instances of salinisation and soil degradation by preventing upstream salt water ingress. This will improve the quality of the agricultural soil.

There is no discernable risk of soil degradation or land damage from chemicals or other harmful substances as none will be used in the construction.