



O THMAR RESERVOIR CAPACITY IMPROVEMENT

Sub-Project ID: 3.4a

INTRODUCTION



Deliverables	<ul style="list-style-type: none">• Remove islands and silt to improve storage capacity• Engineer’s inspection to verify safety of dam• Ground investigation of excavated material to determine suitability for re-use
Beneficiaries	15,000
Budget	US\$ 660,040
Location	Protects Angkaol and Pong Teuk communes and neighbouring parts of Kampot

The O Thmar reservoir holds water for approximately 600 ha of paddy field in Kep Province. Besides Kep province, the reservoir also supplies water to part of neighbouring Kampot Province. O Thmar reservoir is connected upstream to Roness Reservoir, and also has a separate supply catchment from the north. Both these reservoirs date from the Khmer Rouge era (1975-1979). However, Roness is in poor condition and doesn't function properly. Therefore, the retained water level in Roness is kept low and a large amount of water from Roness' catchment directly discharges to O Thmar Reservoir. The two reservoirs are connected by a small canal, making O Thmar a more significant water storage facility for the area. O Thmar is in generally better condition than Roness, having undergone a refurbishment and upgrade in 2003-4, and retains water at full design depth at the present time.

Problem statement

35 years of meteorology data recorded further west along the coast at Sihanoukville indicate a steeply decreasing trend in average annual rainfall since 1983. Climate change projections (cited in the Report on Shoreline Assessment on Climate Change, Cambodia Ministry of Environment) indicate this trend will continue in the coastal area of Cambodia. Storing fresh water will become more important for the coastal areas to reduce the risk of sea water intrusion and therefore salinization affecting crops and people's ability to produce sufficient food. Creating more storage in the O Thmar Reservoir is one of the measures therefore that can support climate change adaptation in Kep Province.

The theoretical capacity of O Thmar Reservoir cannot be fully used, due the presence of islands and areas of higher ground within the reservoir footprint, which limit the storage capacity of the reservoir. There is also significant encroachment of vegetation within the reservoir. With storage capacity limited, the reservoir doesn't provide enough water for agriculture in the dry season. If the islands are removed from O Thmar and the storage capacity raised without increasing the structural loading on the embankment, then additional water storage can be achieved here relatively inexpensively. Resilience to natural hazards refers to the ability to protect lives, livelihoods and infrastructure from destruction or damage, and to the capability to restore areas after natural hazard has occurred. This project seeks to improve the resilience of the affected communes to scarcity of water due climate change and longer periods of drought through the provision of:

- Increased storage capacity of fresh water

Location

Angkaol Commune, Kep Province

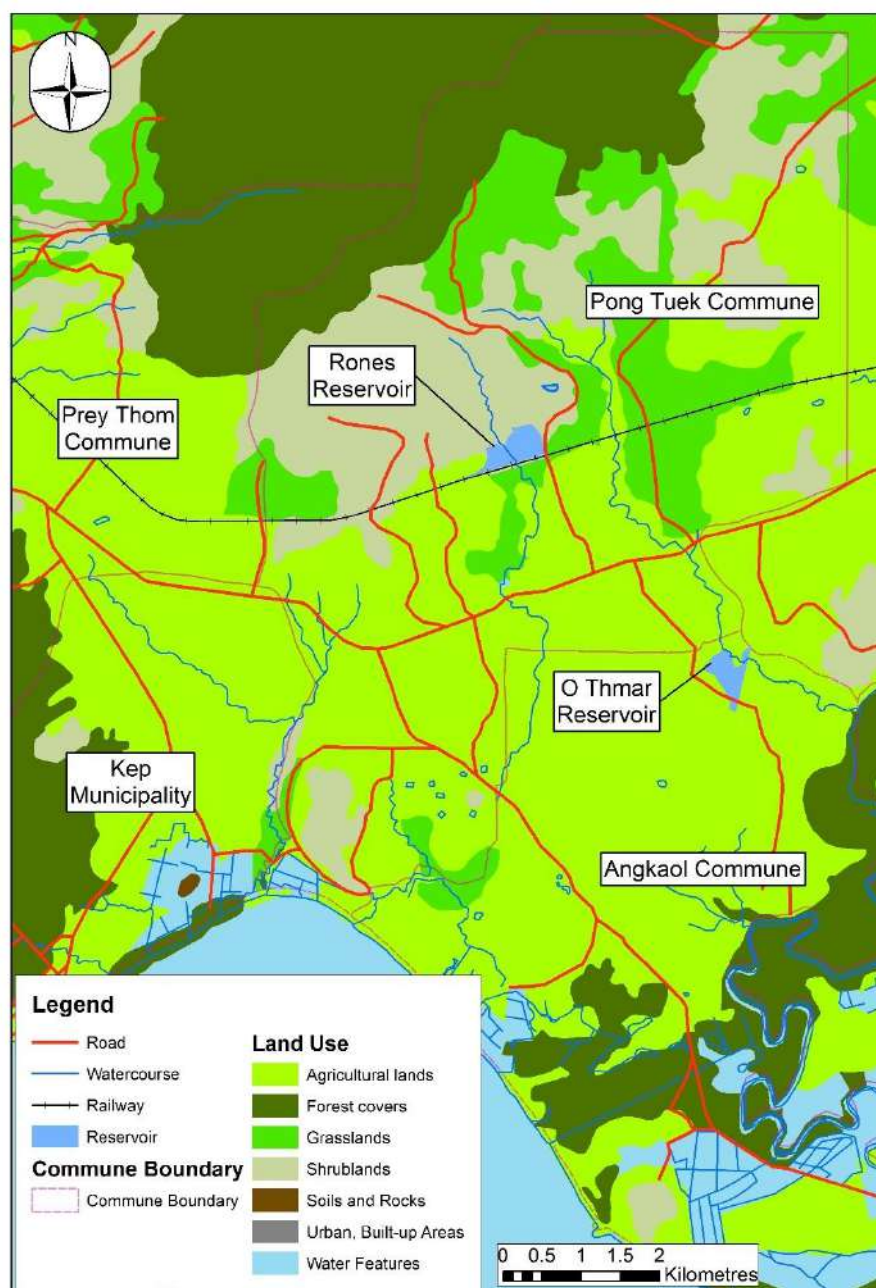


Figure 1 “Map 1 O Thmar and Roness Reservoirs”



Figure 2 “Map 2 O Thmar Reservoir location”

Beneficiaries

O Thmar reservoir provides irrigation and drinking water supply for large parts of Angkaol Commune and part of Pong Teuk commune and can also provide water to people from other local communes (including in neighbouring Kampot province, which is less than 1 km to the east of O Thmar) who drive to site and collect it. There are in the region of 15,000 people for whom O Thmar is the principal or preferred source of water. By improving storage in the reservoir, the probability of downstream areas being affected by flooding is also reduced, and this further benefits the 8,566 residents of Angkaol Commune.

Table 1

Key statistics - O Thmar Reservoir

DESCRIPTION	QUANTITY
Surface area (m ²) *	216,000
Maximum retained water depth at dam (m)	3
Assumed existing storage volume (m ³)	250,000
Volume of potential storage taken up by islands and shallows within reservoir (m ³) *	108,000
Total potential storage following excavation work (existing + additional) (m ³)	358,000

** The surface area is estimated from Google Earth satellite imagery. The volume of storage taken up by islands and shallows is estimated from Google Earth satellite imagery (taken during the dry season with low water levels) and assumed average depth.*

A rice paddy field needs typically 1200-1400 mm per crop (according to the CCCA Report, 2014). This is supported by other studies, (e.g. CAB International 2003), which indicates 1500 mm per crop for sandy loamy soils.

Based on the rainfall data from the Kampot Province in the period between 1981-2004 the lowest annual precipitation is 1320 mm/year (CCCA Report 2014) allowing the farmers to typically harvest just once a year, during the wet season.

- The estimated demand on rice paddy 1200-1400 mm per 1 m², so a volume of 1.2 – 1.4 m³.
- The estimated additional storage capacity by excavating within O Thmar is 108,000 m³.
- Therefore the additional capacity within O Thmar would be sufficient for providing irrigation for a second crop for 8 - 9 hectares of rice field, or even more land for vegetable cultivation (which has a lower water demand).
- 9 ha represent 1.5% of the 600 ha downstream area served by O Thmar reservoir which would be enabled to grow a second crop.

This will have a significant benefit considering the observed trend for longer dry seasons and less annual rainfall as predicted for the area.

Table 2

Irrigation demand and supply by O Thmar Reservoir

DESCRIPTION	QUANTITY
Demand annually	1200 – 1400 mm/year
Dry year 1981-2004	1320 mm/year
Additional storage capacity O Thmar	108,000 m ³
Additional area irrigated by O Thmar	9 ha (= 108,000 m ² / 1200 mm)

Table 3

Annual rainfall at three locations for 1981-2004 (CCCA report 2014)

Table 2: Estimated annual rainfall at 3 locations

	Sihanoukville	Koh Kong	Kampot
Highest in 16 years	4,230 mm/year	3,970 mm/year	2,450 mm/year
Average over 16 years	3,240 mm/year	3,030 mm/year	1,870 mm/year
Lowest in 16 years	2,290 mm/year	2,150 mm/year	1,320 mm/year
Available every 2nd year	3,330 mm/year	3,130 mm/year	1,930 mm/year
Available 4 out of 5 years	2,940 mm/year	2,750 mm/year	1,700 mm/year
Available 9 out of 10 years	2,560 mm/year	2,400 mm/year	1,480 mm/year

Note: The rainfall varies significantly within each province, as illustrated on the map on the previous page

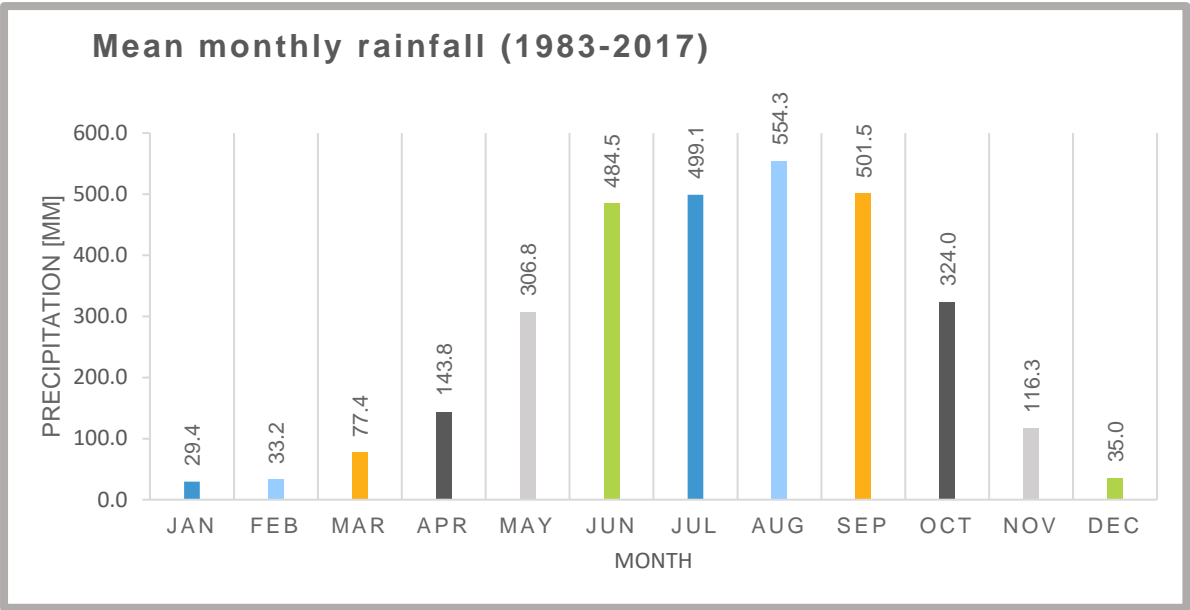


Figure 3 “Chart 1 Mean monthly precipitation 1983-2017 Sihanoukville (Department of Water Resources and Meteorology)”

BUDGET

Inspection and Excavation cost O Thmar Reservoir

The budget is roughly determined by the cost for excavation and estimated amounts of material to be removed.

DESCRIPTION	QUANTITY	UNIT PRICE	COST
Vegetation management (trimming trees, removing scrub) on embankment	60 trees	\$ 9	\$ 540
Detailed inspection of the dam by a qualified dams engineer (same visit as for Roness)	5 days	\$ 500	\$ 2,500
Dams safety investigation, including hydrological, hydraulic engineering and geotechnical studies, to verify dam for additional water storage	40 days	\$ 300	\$ 12,000
Ground investigation – analysis of samples of material excavated from islands to determine suitability for re-use in local construction projects			\$ 7,500
Excavation cost per cubic metre	108,000	\$ 5	\$ 540,000
Transport (included in excavation cost)		-	\$ 0
Excavation equipment	2,000	\$ 39	\$ 78,000
Labour (skilled)	250	\$ 30	\$ 7,500
Labour (unskilled)	800	\$ 15	\$ 12,000
		TOTAL	\$ 660,040

If material is excavated dry, and proved suitable from geotechnical testing, it can be re-used in construction works. The material will be used where possible in local construction works, including investments undertaken as part of the proposed project, such as the new sea flooding embankment at Angkaol, which will require 5,500 m³ of material (investment 3.3), and 15,000 m³ at the Kep Protective Embankment (investment 3.4c), and the low sections of the Prey Nob sea wall, which will require 6,000m³ of material (Investment 3.6). If the material proves unsuitable for this purpose, it will be provided for free as agricultural soil for farmers in the local area. The surplus of approximately 81,500m³ will also be provided for free to farmers in the local area. This will be invaluable to supporting local agriculture and supporting farmers to prevent salt water from damaging their crops.

It is likely that much of the material, including material removed wet by dredging the bed of the reservoir, will be silt derived from upstream soils washed into the reservoir during flood

events, and therefore better suited to agricultural use such as soil dressing (once tested for any contaminants), restoring nutrients to local soils. This material will be stockpiled locally and provided at a discounted rate to local farmers for their collection.

DATA COLLECTION

Inputs

The following input is used as data source for benefit calculations and water demands for rice cropping:

Climate-resilient irrigation guidance paper, 2014. Coastal Adaptation and Resilience Planning Component, Cambodia Climate Change Alliance (CCCA)
 Water Productivity in Agriculture: Limits and Opportunities for Improvement (eds J.W. Kijne, R. Barker and D. Molden), CAB International 2003.
 Report on Shoreline Assessment on Climate Change, Cambodia Ministry of Environment

The Kep Provincial Department of Water Resources and Meteorology advised that they have 10 water storage reservoirs, 9 of which are in Pong Teuk commune. Two of these, Roness and O Thmar, are considered a priority for attention. They consider Roness reservoir as the top priority for rehabilitation, followed by O Thmar. There is a connection between the two, with Roness further upstream. There is also a separate natural inflow to O Thmar which flows directly from high ground to the east of Roness.

Consultations

The following governmental organisations were consulted:

17-10-2018 – Kep province Department of Water Resources and Meteorology

18-10-2018 – Angkaol Commune

19-10-2018 – Pong Teuk Commune

O Thmar reservoir appears to be in good condition with the embankment, spillway and the water gates serviceable and the reservoir currently holding full volumes. Some minor embankment repairs and vegetation management on the downstream side should be undertaken but the reservoir is generally in much better condition than Roness. O Thmar reservoir can relatively easily benefit more livelihoods by increasing the storage capacity while maintaining the same dam height. In combination with the two other investments on canal rehabilitation and water gate repair the excavation of high ground within O Thmar leads to significant improvements in local water resilience, being more able to store fresh water that is becoming scarcer due to climate change.

Based on community consultations the area irrigated by the O Thmar reservoir is estimated as 600 hectares. Figure 5 supports the information given by the Commune on the irrigated area.

Site Records

O Thmar dam is a 4m earth embankment impounding an area of water of up to 3m depth at the dam, with manual sluice gates (Figure 1) to allow downstream discharge into irrigation canals. The 1.2 km length embankment at O Thmar is a maximum of 4m above adjacent downstream ground level, with an approx. 4m wide crest, 1 in 3 side slopes maintained in good condition with limited vegetation (figure 2), a series of manual sluice water gates for controlling downstream flow into irrigation channels and an automatic radial gate to function as an overflow into the spillway (figure 4). One manual underpass is installed for flushing sediments. The dam condition appears reasonable but there is a small amount of vegetation on the downslope side (see Figure 2) which should be managed to facilitate inspection.

The upstream catchment is approx. 1,980 ha and the area downstream which would potentially be inundated by a breach 1,415 ha across largely rural and more sparsely populated countryside. There is no major concentration of infrastructure downstream of O Thmar, but up to 8,000 people live in low-lying, dispersed farming communities downstream. There is some erosion around the wing walls on the downslope side of the embankment adjacent to the sluice gates. It was observed that much of the area within O Thmar reservoir comprises islands clear of the water surface and there is much vegetation on the water surface within the impounded area, which extends to approximately 21 hectares. It was apparent that, as the dam is in apparently good condition, there is the potential for the islands in this reservoir to be removed in order to improve storage capacity without changing the structure of the dam itself. The underlying geology at the dam is described as 'Quaternary Pediments', which indicates alluvial sedimentary material which can be relatively easy to excavate.

Satellite imagery shows that approximately 50% of the area is silted and overgrown with vegetation such as water lilies, although this could be misleading if the photographs were taken during the dry season. The retained water depth is approximately 3 m at the dam and can be expected to be less further upstream. For the purposes of this investment we have estimated that 108,000 m³ of material could be removed.

IMPLEMENTATION

Design

Although the dam appears to be in good condition, comparison with other local dams and the knowledge that they were all built during the Khmer Rouge regime (1975-9) when modern engineering standards were unlikely to be adhered to raises concern over the long-term safety of the structure. Therefore we propose to carry out an inspection by a qualified dams engineer and a hydrological / hydraulic engineering and geotechnical investigation of the dam. While the proposed works do not increase the loading on the dam, they will result in larger volumes of water being stored and so potentially greater risk in the event of a failure, hence the need to undertake the detailed inspection.

The inspection can be done in conjunction with the proposal for facilitating refurbishment of the Rones dam. A qualified dams engineer should visit and carry out a detailed inspection of the dam, spillway, sluices and any other structures. This would be followed by a detailed investigation study, scoped as necessary under the instruction of the dams engineer following the inspection. This study will identify any remedial work needed to ensure the continued safe operation of the dam and reservoir.

Geotechnical Investigation – Islands

It is intended to beneficially re-use as much material excavated from the reservoir as possible. Some of the material may be suitable for use in the proposed sea flood defence embankment at Angkaol (see other investment sheet for details), 3 km to the south of O Thmar. In order to determine suitability a geotechnical investigation is proposed for the areas to be excavated. This amounts to laboratory testing of samples taken from the excavated material and analysed as follows:

Laboratory testing (it is assumed no rock material will be encountered).

Non-cohesive soils

The following tests are required on non-cohesive soil samples:

- Particle size analysis (classes/sieve dimensions);
- Hydrometer tests on selected samples;
- Triaxial tests (consolidated drained, minimum/maximum density).

Cohesive soils

The following tests are required on cohesive soil samples:

- Atterberg limits;
- Moisture content;
- In situ density (by undisturbed samples);
- Un-drained shear strength (pocket penetrometer and/or torvane in field);
- Triaxial tests (consolidated undrained);
- Particle size analysis (classes/sieve dimensions);
- Hydrometer tests on selected samples;
- Consolidation test.

Community Engagement

The local community have been proactive in requesting improvements to the local water supply and are expected to be fully supportive of the project. The contractor must ensure that any disruption to the local community during the works is minimised and, where possible, local labour is employed.

Construction

It is recommended that the excavation work is carried out in the second half of the dry season. This will mean retained water levels are lower, allowing access for machinery to reach parts of the reservoir bed and the island areas safely in the dry. It will also mean that material can be excavated dry and will not then need to be drained before being removed from site (if material is removed wet it is heavier and would require more transport and incur greater cost), and it will minimise the mobilization of wet silt within the reservoir. It is proposed to re-use as much of this material as possible, where it is suitable, in local construction projects and this would not be possible if the material is removed wet, as then it would lack structural cohesion. However, any accumulated silt at the bottom of the O Thmar reservoir can also be removed using conventional dredging methods, by excavator from a pontoon and disposed of (possibly by spreading on fields) to further enhance the storage capacity. The works will probably need to proceed over two consecutive years as removal of 108,000 m³ of material will require 13,500 HGV movements (assuming 8 m³ vehicle capacity).

To allow machinery access into the reservoir to enable excavation, a temporary road access from the upstream side of the reservoir into the area where the islands are is required. **Machinery should NOT access the reservoir bed from the dam, as this would damage the dam structure.**

It is essential to the stability of the dam that the excavation does not take place within close proximity of the upstream toe of the embankment, the proximity to be determined by the

qualified dams engineer during the inspection. However, subject to instruction by a qualified dams engineer, any vegetation rooted in this area and on the upstream face of the dam should be managed to prevent obstruction of the spillway or damage to the dam. Nowhere in the reservoir should the bed be lowered to a depth below the cill of the outflow sluice gates, as any deeper water could not then be distributed.

During the excavation works and into the following rainy season a daily inspection of upstream and downstream slopes along the entire length of O Thmar dam must be carried out to observe any changes in the dam. Dams are at their most vulnerable during construction or modification, and although there is no intention to change the dam configuration in any way, the excavation work will result in changes in both storage capacity and flow paths within the reservoir, and this has the potential to affect the dam.

Contractor Requirements

The maintenance work on the reservoir requires a specialist contractor who is familiar with the risks involved. The following precautions should be considered while selecting a contractor.

- Compliance with international health and safety standards
- Experience with construction, maintenance and dredging reservoirs or similar infrastructure
- Trained staff, especially working near and on waterbodies.
- Before executing the maintenance work a check on Unexploded Ordnance (UXOs) is mandatory
- Access routes for excavation machinery to reach the reservoir bed should be from the upstream (shallow) side of the reservoir and not off the dam itself.

Further information about the Environmental and Social safeguard provisions of the project can be found in Part II, Section K, and Annex 3 to the proposal.

Key Risks & Safeguarding Issues

Table 3 is accounting for all the Environmental and social safeguarding issues involved in the O Thmar reservoir rehabilitation. Labour rights and safety are of particular interest by restoring the reservoir. Choosing a contractor with the right requirements in this project is essential for risk mitigation on the social safeguards. Furthermore, the educational part on water use and reservoir maintenance provides for a more efficient use of natural resource, by limiting the wasting of fresh water resources.

PHOTOS



Figure 4 “underpass O Thmar sluice”

Figure 5 *“O Thmar Embankment”*



Figure 6 *“Vegetation on the surface of O Thmar Reservoir and upstream face of the dam, adjacent to the spillway”*



Figure 7 *“O Thmar reservoir automatic radial gate and spillway”*



Figure 8 *“irrigated rice paddy fields Kep province (Kep Province Department of Meteorology and Water Resources)”*



Table 1*Environmental and Social Safeguard and risk mitigations incorporated*

ENVIRONMENTAL AND SOCIAL SAFEGUARD PRINCIPLE	RISK MITIGATION ACTIONS INCORPORATED IN THE DESIGN
<p><i>Compliance with the law</i></p> <p>projects/programmes supported by the Fund shall be in compliance with all applicable domestic and international law.</p>	<p>O Thmar Reservoir is classified as state public land and can be accessed by a public road. All actions have checked and are compliant with relevant national laws, as detailed in the proposal Part II, Section E.</p>
<p><i>Access and Equity</i></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>Currently there are no signs of unequal sharing in the water supply. The effort of people further away from the source is bigger than those close by, the measures proposed will not change the accessibility and the equitability of the source. The measures only enlarge the availability of fresh water to all beneficiaries.</p>
<p><i>Marginalised and Vulnerable Groups</i></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>The improvements on the water system will not marginalise vulnerable groups.</p>
<p><i>Human Rights</i></p> <p>Projects/programmes supported by the Fund shall respect and where applicable promote international human rights.</p>	<p>There is no evidence to suggest that human rights will be violated. Rights issues concerning land, women, labour and indigenous people are addressed separately in this sheet.</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 poor 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 in the 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.

The works all involve work on public state-owned land and are accessed by public roads and tracks. There is no one living on or immediately adjacent to the proposed construction area and as such there is no discernible risk of resettlement

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.

The water reservoir is not appointed as natural habitat protection area.

The reservoir is not used for fishery purposes.

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.

The waterbody in its current state is home to vegetation and water plants, but has no official status as natural habitat. O Thmar is a man-made reservoir and as such has no status as a biological reserve.

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 enhancement will increase the resilience of the population to climate change. While the excavation operation will involve some machinery, the long-term operation of the reservoir and associated infrastructure will not emit GHGs that cause climate change.

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.

Undertaking the excavation work when water levels are low will minimise the risk of mobilising sediment into the water supply.

Without safeguarding actions, there is a risk that the material excavated from O Thmar could be improperly disposed of, causing pollution. Kep Province lacks landfill capacity or modern recycling facilities. Therefore, the following solution has been proposed:

As described above, 5,500m³ of the excavated material will be used in the embankment at Angkaol (investment 3.3, about 2km away). 15,000m³ will be used for the Kep protective embankment (investment 3.4c) and 6,000m³ will be used in the Prey Nob embankment (investment 3.6). The remaining approximately 81,500m³ of material will be distributed for free to local farmers.

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 storage of fresh water increases the access to fresh water.

The construction will not use any hazardous materials or chemicals that could damage public health.

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.

The activities at O Thmar will not harm cultural heritage. There are no sites of cultural, spiritual or religious heritage in or around the reservoir or its adjoining canals.

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 reservoir enhancement provides means to the local community to conserve more fertile and productive land. With a larger amount of fresh water availability, a larger stretch of agricultural land can be used or productivity on current plots can be enlarged.

Please see pollution prevention and resource efficiency, above, for a description of risks foreseen and actions proposed to dispose of the material dredged from the bottom of O Thmar