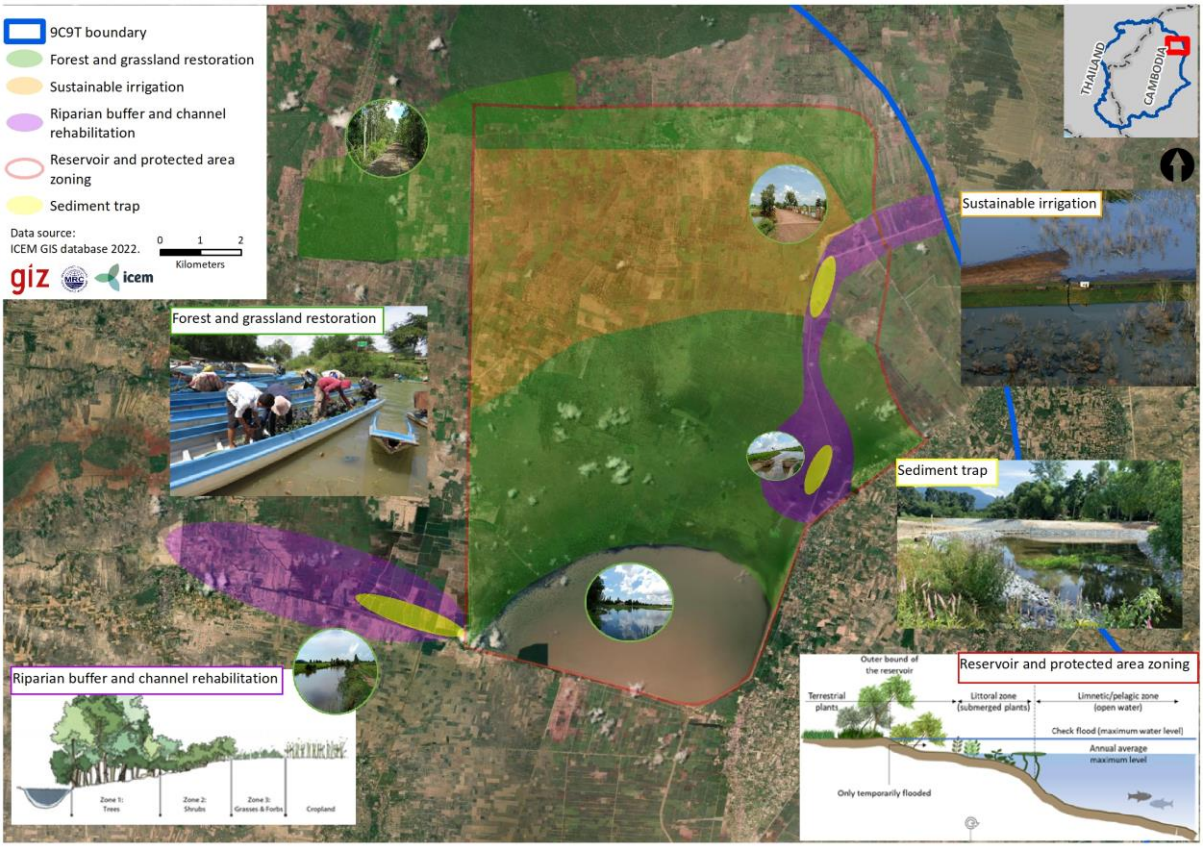
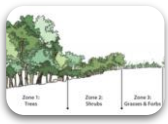
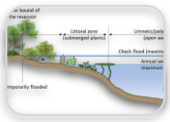
PROJECT 6: RESERVOIR – ANG TRAPEANG THMOR LAKE AND PROTECTED FOREST, CAMBODIA

1. Project Overview





1. Riparian buffer



2. Reservoir zoning

3. Catchment water management

5. Sediment trap

6. Forest restoration and rehabilitation

13. Sustainable irrigation measures

15. Agricultural field buffer

Project 6 is concerned with protected area encroachment, drought and erosion risk. The project objectives for this landscape are:

- Define measures to foster sediment management, watershed rehabilitation and protected area restoration and biodiversity safeguards, including protected area management, forest restoration, riparian buffers and water management; and
- Work together with the lead and supporting agencies, as well as local and provincial stakeholders to ensure an integrated approach to protected area, drought and erosion management is implemented, that aligns with the 9C-9T Masterplan and Action Plan.

Table 1: Project 6 – Master Plan implementation factors

Item	Description
Alignment to 9C-9T Masterplan	• **Focal Area 2**: Manage urban and rural flood and drought to reduce risk • **Outcome 2.2**: Strengthened rural flood and drought resilience through ecosystem-based planning tools and adaptation interventions • **Output 2.2.2**: Develop spatial zoning and safeguards across rural landscapes, especially relating to existing and new infrastructure, and implement by installing sediment traps, conducting dredging to maintain capacity, maintenance to prevent encroachment of agriculture into reservoir banks, and establishing vegetated buffers along drainage and transport corridors and along allotment boundaries
Implementing stakeholders	• *Lead agency (Cambodia)*: Ministry of Water Resources and Meteorology (MOWRAM) and Ministry of Agriculture, Forestry and Fisheries (MAFF) • *Supporting agency (Cambodia):* Ministry of Environment (MoE) and provincial government
Alignment to agency priorities	MAFF is responsible for governing activities of agriculture, forestry and fisheries and MOWRAM is responsible for governing activities of flood management in the catchment

1.1. Site description

Project 6 covers Ang Trapeang Thmor (ATT) Lake, Protected Forest and catchment, Cambodia. ATT, was established in 2000 by Royal Decree. It comprises 12,650 hectares, is designated as a protected landscape, as well as an Important Bird and Biodiversity Area (IBA), including the ATT Sarus Crane Conservation Area. The site is the single most important non-breeding season feeding area for Sarus Crane globally and supports several other globally threatened species.

The landscape is characterised by a large artificial reservoir, deciduous forests, natural flooded grasslands, inundated forests and rice fields. During the dry season, only the south-eastern corner of the reservoir remains inundated; however, at the height of the wet season, over 80% of the area is inundated. Water levels are typically shallow, and in the wet season, the water depth at the sluice gates is approximately 1.5m, while the maximum water depth of the reservoir is only 3m. The minimum water depth is 0.2m in June through August, during which the ATT water storage is 60 million m^3. When this low water level is reached, any water supply request from the reservoir for irrigation is rejected.

During the Angkorian period, from the 10th to the 13th century AD, a major causeway was constructed through the area, which led to increased water accumulation to the north, mainly of surface runoff. In 1976, an 11 km stretch of this causeway was converted into a dam and a 9 km dyke constructed perpendicular to it. However, the planned irrigation reservoir was never completed, and until recently only the south-eastern corner of the reservoir remains inundated during the dry season.

The development of the dam to the south enabled the creation of a larger reservoir aimed at providing water storage and irrigation, including via irrigation canals, for rice cultivation downstream of the dam. During the 1990s, an influx of refugees from neighbouring provinces and from Thailand increased land pressure on the area. The lake provides opportunities for a range of ecosystem services, includes non-timber forest products (NTFP), fishing grounds and wetland activities. Within the core protected area, no agricultural activity is permitted, including grazing of livestock, however fishing is allowed, although enforcement is a challenge.

Two key water inflow channels support water availability in ATT reservoir:

(i) The 34km long Sreng canal diversion was recently constructed to support seasonal drought resilience (Figure 6). The canal is the main trunk to link the Sreng River with the ATT reservoir.

(ii) A water inflow channel from the Pon Lay reservoir connects to the southeastern corner of ATT reservoir. Many irrigation channels are connected to the channel in the long stretch between the two reservoirs, extracting water and reducing the water flowing into ATT. During the dry season there is no water in the Pon Lay reservoir and inflow channel.

Two community forests are present within ATT:

(iii) The Konkleng Community Forest, in which there are 180 households and a forest area of 2,873 ha, was officially registered as of 2009 with the state forest administration. The forest community was established in 2000. There are a few NTFPs, including mushrooms and honey, which provide additional, non-agricultural income for the local communities. Agricultural land for the 180 households is located outside of the forest area; and

(iv) There is an additional Community Forest named Prey Daurm Rang in Prasat Vin village. The forest area comprises 400 ha and 100 households, dependant on the forest.

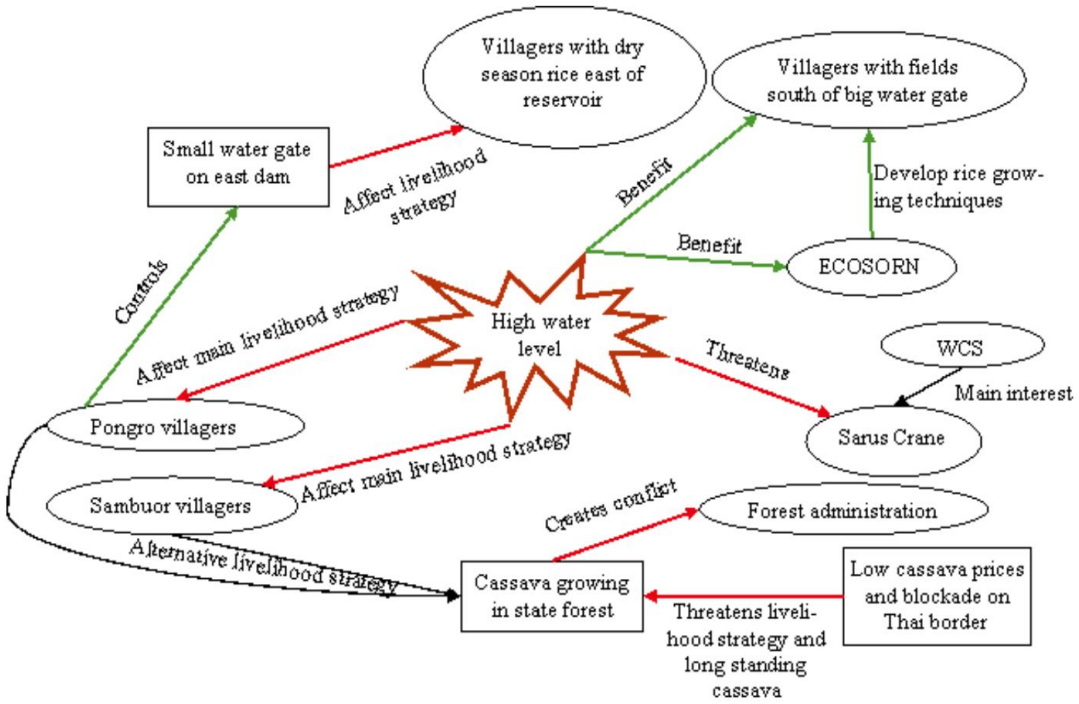
1.2. Flood and drought drivers and impacts

1.2.1. Drivers

Lack of integrated water resource management principles

Sediment management and watershed rehabilitation at ATT are the priority interventions for this landscape. Through consultation, it is understood that the main water management concern for ATT is water allocation between upstream and downstream stakeholders and communities, and the associated management of the reservoir gates. There has been historic conflict between the local villages adjacent to ATT, who have direct access to the reservoir, and other downstream villages who reply on water supplied from the reservoir, over the control of water resources including for irrigation purposes.

Figure 1: (top) historic water-related conflict at ATT; (bottom) location of villages in ATT area



Soil erosion and sedimentation problem

The characteristics of the canals – in particular to the north (Sreng) but also to the south (irrigation canals) – with partially unvegetated, eroded banks, are very likely a source of erosion bringing additional sediment into the reservoir. Vegetated areas have been replaced by agricultural land, increasing erosion into rivers and reservoirs. Agricultural practices, such as furrows in the direction of drainage, exacerbates erosion and sedimentation. Sedimentation in the downstream canals are also caused by water with suspended sediment, discharged from ATT reservoir when water supply is required for rice irrigation.

Encroachment of the reservoir and protected area and forest to agriculture transitions

Geospatial analysis of the landscape area demonstrates significant land cover change and vegetation disturbance over the last 20 years, particularly within the northern extent of the protected forest area.

Seasonally inundated areas of the reservoir support grassland expanses, called 'Plong', which is critical feeding habitat for the Sirus Crane. The northern portion of the reservoir is inundated for a short period each year and has been extensively converted to wet rice agriculture. This has resulted in progressive encroachment of the reservoir area during periods of low water level.

Access restrictions to the protected area by local communities has generated resource management challenges and pressures. Conflicts have arisen around the designation of cultivated lands in/around the PA, leading to historic renegotiation of agricultural vs. biodiversity zones, such as between the International Crane Foundation (ICF) and Pongro and Sambuor villages in 2003.[1] The loss of agricultural land associated with protected area user restrictions has resulted in encroachment of other crops in neighbouring areas, such as the cultivation of cassava within the largely deforested forests to the east of ATT.

[1] Wan, A. et al. 2009. Dammed protected areas impact on nature and local livelihoods, Ang Trapeang Thmor, Cambodia

Figure 2: ATT Protected Area landscape

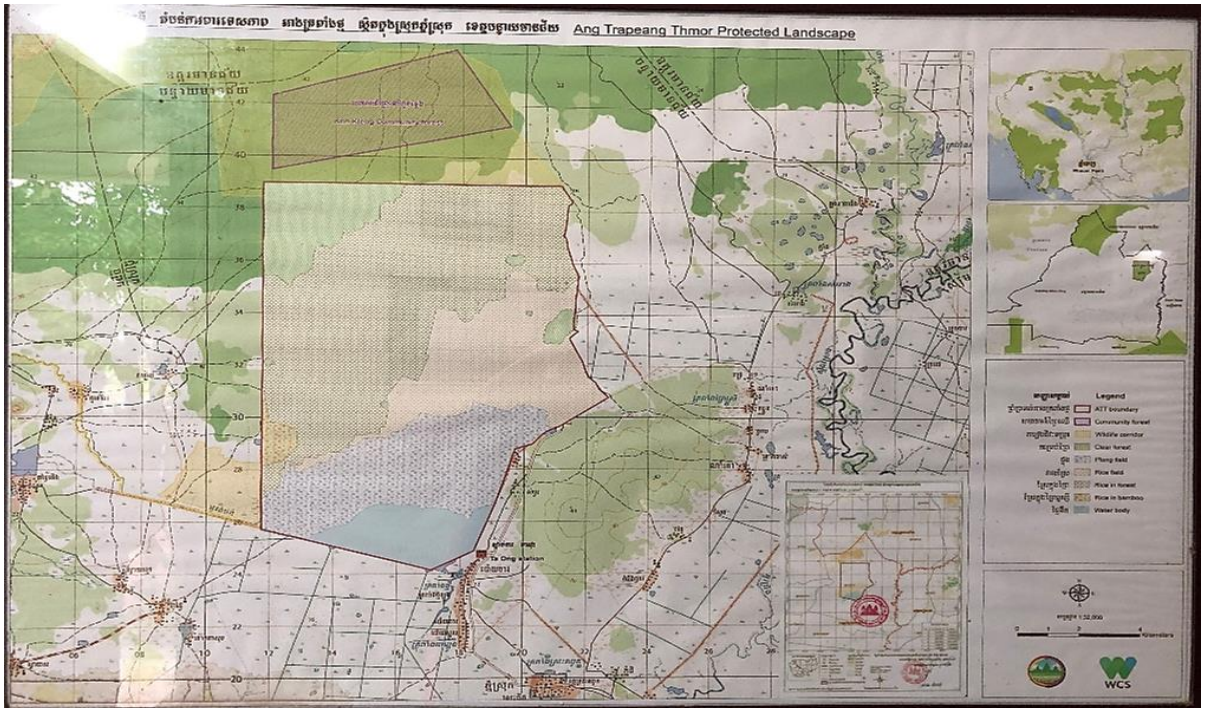
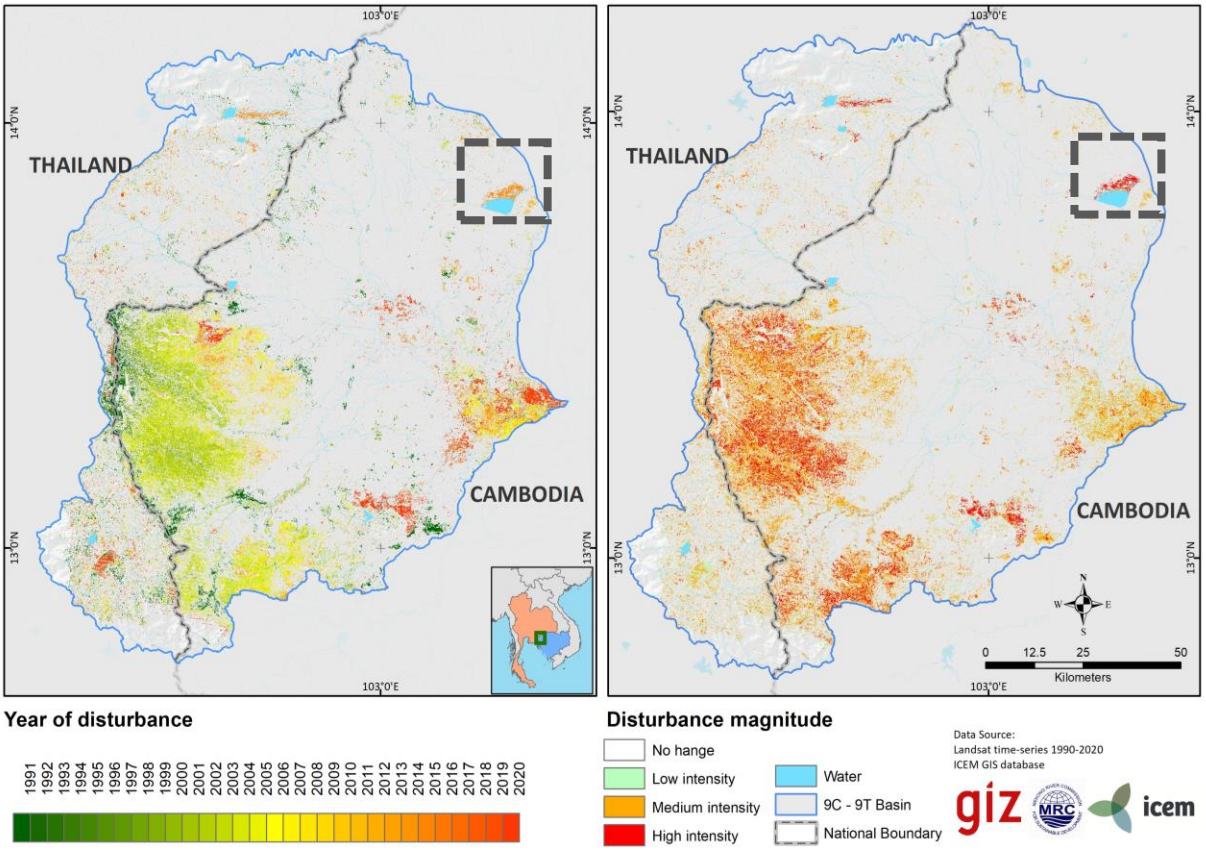


Figure 1: Vegetation disturbance at ATT



Reduced rainfall and drought

The northeast portion of the 9C-9T sub-basin, in which ATT is situated, has been identified as a region of particular concern for drought frequency and risk (Figure 4), to worsen significantly with climate change and a projected reduction in annual precipitation (Figure 5). The area to the east of the reservoir, covered extensively by agriculture, is one of the highest drought risk locations in the 9C-9T sub-basin.

Figure 4: 9C-9T MODIS Normalized Difference Water Index (NDWI) drought frequency months

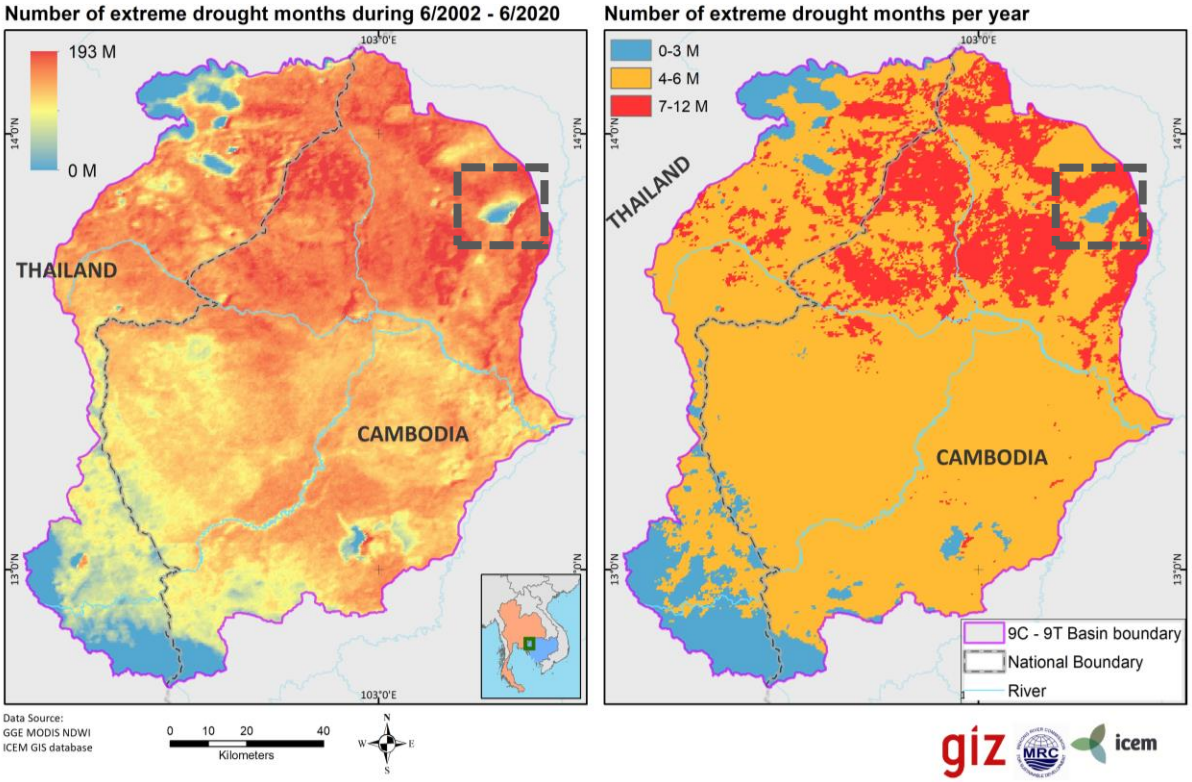
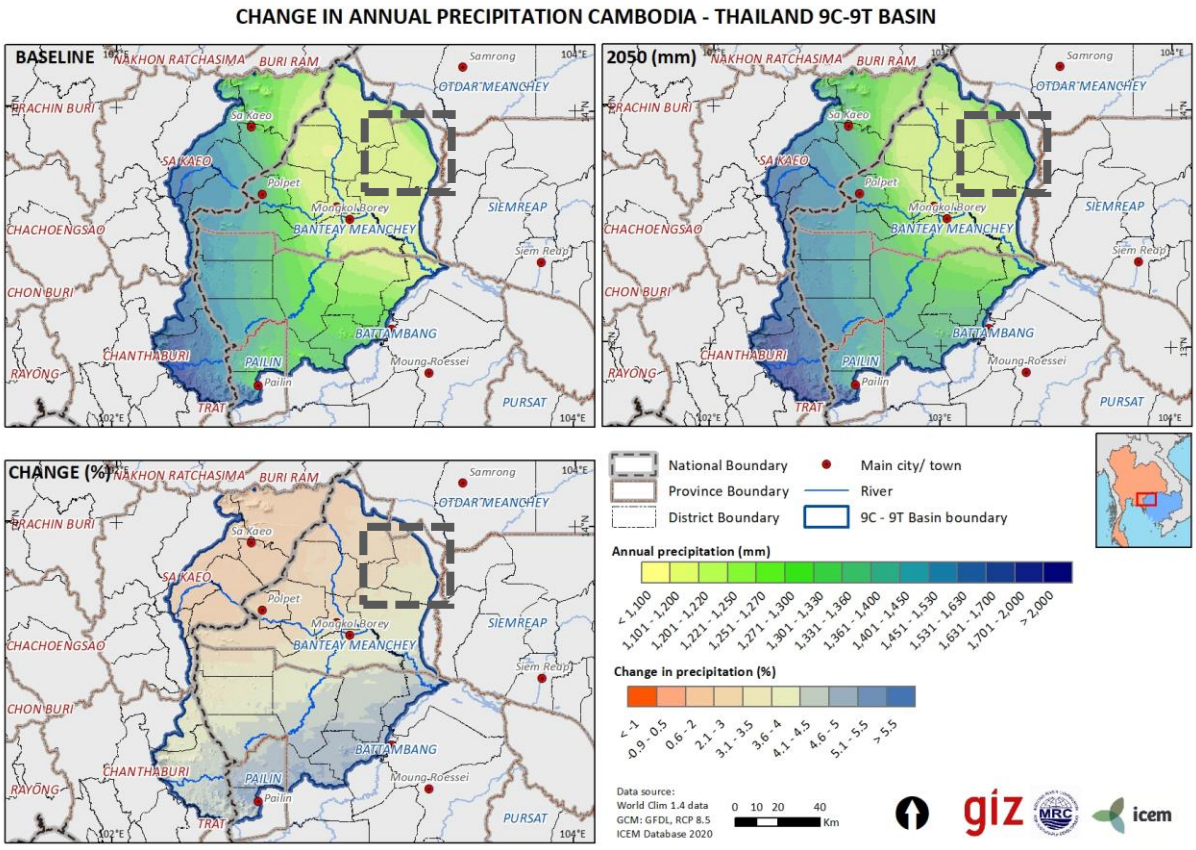


Figure 5: Scenario changes in annual precipitation – baseline vs. 2050



1.2.2. Impacts

Loss of water storage, sedimentation and water quality

Sediment from the canals settle in the reservoir, resulting in a loss of water storage and reducing its life span. This leads to reduced flood mitigation functions and a decrease in drought resilience; a significant risk when coupled with the project future trend of increasing drought/reduced rainfall. The use of chemicals for agriculture also influences the reservoir water quality.

Forest and grassland loss and biodiversity risk

Encroachment of the reservoir and its catchment over time has significantly reduced the forest coverage within the protected forest landscape. There are now only two community forests remaining within ATT; the Konkleng Community Forest, and the Prey Daurm Rang.

The competing water resource dynamics also impact on ecosystem services in the catchment. When the flood water level in ATT reservoir is elevated for extended periods, the 'Plong' grasses become oversaturated and destroyed. Despite the grass stem length increasing in a response to the flood waters, the stems are so fragile that they are destroyed by strong water flow. MOWRAM may be planning to increase the retention volume of the reservoir from 80 to 200 million m^3, resulting in a more extensive inundation area, threatening remaining grasslands.

The Plong grassland zone is a significant feeding location over 200 species of birds, and other wildlife. The birds are largely present in the dry season from January till May. Their feeding ground is threatened by chemical fertilizers, herbicides and pesticides used by farmers. The rice fields had been cultivated for decades prior to ATT management. Previous attempts to relocate agricultural land outside of the ATT reservoir and protected area have failed due to a lack of available compensation and land.

Those development trends present a risk to the resident flora and fauna – land and aquatic – and results in a fragmented habitat and loss of biodiversity, significantly undermining the value of the protected area ecosystem.

1.3. Nature based and hybrid solutions project concept

1.3.1. Concept design of NbS

Measure 1: Riparian buffer

The recently constructed 34km long Sreng canal diversion was constructed to support seasonal drought resilience (Figure 6). Cross-sections do not change significantly along the full length. A road network follows on both sides of the canal which is some 9 m in width, connected by bridges at regular intervals. The roads and concrete banks are along the entire length either side of the main waterway (sparsely vegetated in some areas). Adjacent land comprises largely agricultural land, presenting a challenge for extending a vegetated buffer further.

Figure 6: Sreng River canal diversion

The Sreng canal inflow could present locations for possible NbS interventions, including the planning and design of riparian buffers and a natural canal and wetland system, with no dry season flow. Such interventions could be undertaken solely within the 9C-9T boundary area (approximately 10 km), even so a larger intervention would create more impact.

A vegetated strip either side of the canal is recommended at a width of a minimum of 15m wherever practicable, in line with good practice design (see Measure 1, Annex 1). The vegetative buffer strip should comprise a mix of native species to ensure buffer integrity. Community representatives explained that acacia trees have been planted extensively throughout the ATT landscape, along roads and fields, in order to harvest wood, create shade and reduce erosion. Concerns were raised about nutrients losses, including reduced rice yields next to the acacia trees. The community members suggested to introduce and plant the Neem tree (*Azadirachta indica*, khmer: sdaw) as a native and affordable alternative as potential buffer vegetation.

During the field mission, it was noted that Cambodia National Mekong Commission (CNMC) and Provincial Department of Water Resources and Meteorology (PDOWRAM) raised concerns regarding the plantation of trees next to canals (i.e. riparian buffers) due to MOWRAM regulations.

The Pon Lay reservoir connects to the south eastern corner of ATT reservoir (Figure 7). Many irrigation channels are connected to the channel in the long stretch between the two reservoirs, extracting water and reducing the water flowing into ATT. During the dry season there is no water in the Pon Lay reservoir and inflow channel. Opportunities may exist for NbS interventions, including the design of a natural canal system, with no dry season flow.

Figure 7: Pon Lay reservoir and area

Dredging: This erosion and sediment problem means the canal and reservoir requires regular dredging. With the addition of the buffer strips, the sediment problem could substantially be improved and dredging interval prolonged. The option of canal bank stabilization would also reduce erosion. Dredging has the potential to disturb the riverbank and aquatic ecological networks, whilst it is being established. These impacts must be factored in when planning the buffers and dredging schedules.

Measure 2: Reservoir and wetland zoning

Reservoir zoning is the delineation of one or more aquatic zones within a reservoir at its maximum extent (further detailed in Measure 2, Annex 1). Zoning is an essential management tool in the case of this reservoir, which has such important biodiversity values. Zoning would be guided by good practice Biosphere Reserve categories.[2] Consequently, three core zones are proposed for the reservoir, to be further assessed with fine tuning of boundaries:

- Core zone – strict protection and conservation of habitats and water security;
- Buffer zones – for ecologically sustainable activities such as eco-tourism, environmental education and local knowledge and traditions with limited interference; and
- Transition zone – reduced restrictions for sustainable activities, ecosystem service use and socio-culturally sustainable economic and human activity. This could include a seasonal flood area permissible for temporal sustainable agriculture; agriculture that adheres to sustainable irrigation practices, without degrading soil quality and using harmful pesticides.

The variation in the reservoir's extent and volume during the wet and dry season, and associated temporary agricultural encroachment, presents a challenge for implementing zonation. Agriculture and fishing are core livelihood activities at ATT and managing water supply and demand along with

[2] UNESCO (2021). Technical Guidelines for Biosphere Reserves. https://en.unesco.org/news/technical-guidelines-biosphere-reserves-new-tool-mab-programme.

flood and drought risk is a priority. The local community needs to be suitably acknowledged and engaged from the outset of the planning process for this intervention.

Agreeing on the zoning and management objectives for each zone (including permissible activities) is an important part of closely involving local communities, conservation organisations and other stakeholders for the participatory and sustainable management of the reservoir. As there are activities already present in/around the reservoir, including in sensitive areas, future discussions will need to assess and propose management interventions for these. All illegal activities should be prohibited after the approval of the zoning plan.

Measure 3: Catchment water management plan

Water management practices should follow a similar approach to that proposed for Kamping Puoy reservoir. The water management plan should consider the entire catchment of ATT. Key water management interventions include the following (further detailed in Measure 3, Annex 1):

- Regulation and guidelines about sustainable water use associated with ATT and its catchment;
- Regulations and guidelines on the management of ATT reservoir relating to protected area management and biodiversity safeguards;
- Improvement in water use efficiency associated with ATT and its catchment;
- Hydrological assessment to balance agriculture water consumption upstream and sustainability of the ATT reservoir downstream.

A thorough analysis of the current situation, stakeholder analysis, and projection of demands is needed to find optimal management rules and an acceptable water allocation scheme. Currently there is no effective cross sectoral management structure or process which brings together the needed national sectoral agencies and local authorities.

Measure 5: Sediment trap

Sediment traps are proposed upstream of the reservoir, near the reservoir inflow sites of the Sreng canal and the Pon Lay channel. The establishment of small multiple functioning sediment traps/pools (through NbS and hybrid structures) offers significant potential within this landscape. Such interventions would help to collect sediment before it enters the reservoir to prevent sedimentation and decreased water storage capacity.

Measure 6: Forest and grassland restoration

Despite the fragmented and degraded ecosystem to the north of the reservoir with only a fraction of the original forest remaining, opportunities exist for developing nodes, stepping stones and corridor networks of dry and flooded forest (identified on project overview map). Flooded forests are an important component of wetland ecosystems, providing fish nurseries and habitats as well as carbon storage. In addition, aquatic vegetation as part of wetland restoration needs to be established alongside the reforested areas providing important natural wastewater treatment functions.

Opportunities exist to identify possible wetland zones and support the rehabilitation of the Plong grassland. Agricultural buffer zones along and within croplands can complement and add to natural vegetated corridors across the landscape. Rehabilitation and restoration of forest and grasslands within the protected area will provide erosion control, water regulation, habitats and other ecosystem services.

Measure 13: Sustainable irrigation measures and Measure 15: agricultural field buffers

Due to the drought risk and extensive agricultural practices within the reservoir catchment, sustainable irrigation measures are proposed for ATT (see Annex 1, Measure 13). Field trenches and small-scale bioretention ponds (including within the reservoir zone) provide opportunities for improved water resource management by farmers. Field trenches involve ploughing to the right angle of a field's slope, filtering runoff water, reducing soil degradation and enhancing infiltration of surface

run-off and soil moisture. Agricultural buffer strips using native vegetation, also offer opportunities to improve ecological connectivity, reduce sedimentation and enhance infiltration.

1.3.2. Project benefit

- Regulation and guidelines about sustainable water use associated with ATT and its catchment;
- Establishment of reservoir zones to ensure effective reservoir management, habitat conservation, water security and support for ecologically sustainable activities;
- Improvement in water use efficiency associated with ATT and its catchment;
- Multi-functioning sediment traps to prevent sedimentation and decreased water storage capacity of the reservoir;
- Conservation and restoration of degraded forest and grassland area within the ATT protected area, bringing nature back;
- Natural buffer development for over 15 km of existing degraded channels;
- Sustainable agricultural measures to reduce encroachment, support and more effective cultivation and water management in the ATT catchment.