RURAL LANDSCAPE POLICY BRIEF

Economic analyses of nature-based solutions for flood and drought management in the 9C-9T transboundary sub-basin of the Mekong in Cambodia and Thailand, focusing on the rural reservoir landscapes of Ang Trapeang Thmor and Sompoi

INTRODUCTION

In 2018, Cambodia and Thailand established a partnership for the management of the 9C-9T sub-basin of the Mekong River within the National Indicative Plans, the collaborative framework of the Mekong River Commission (MRC). The cooperation is facilitated by the MRC with support from Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) funded by the German Federal Ministry for Economic Cooperation and Development (BMZ). The goal of this agreement is to improve joint planning and implementation in the sub-basin, aimed at enhancing resilience to floods and droughts. A 9C-9T Flood and Drought Master Plan has been developed and endorsed by Cambodia and Thailand in December 2021 under this programme of cooperation, with implementation of the plan started in 2022.

Nature-based Solutions (NbS) for addressing the challenges posed by floods and droughts in the 9C-9T sub-basin have been developed as part of the collaborative planning process with National Working Groups in each country, chaired by the Cambodian Ministry of Water Resources and Meteorology (MOWRAM) and the Thai Office of National Water Resources (ONWR) under the auspices of the MRC. The process initiates definition of projects, which were key outputs agreed upon and specified in the 9C-9T Flood and Drought Master Plan and Action Plan[1]. Initial conceptual designs for NbS projects in preselected demonstration landscapes have been selected and designed to be implemented under the Master Plan (Figure 1). The NbS project concepts, will be further developed with lead implementing agencies during Master Plan implementation from 2023.

KEY POLICY MESSAGES

1. The cost benefit analysis presents a robust case for the further investment in NbS, in rural areas with anticipated core benefits for improved water availability and reducing the operation costs and extending the operational lives of reservoirs, associated with a reservoir catchment rehabilitation. The analysis illustrates that NbS presents an economically efficient means of building resilience against flood and droughts. Natural systems can often adapt and self-regulate, reducing the need for continuous human intervention and expensive upkeep. The analysis demonstrates that prioritizing NbS as a strategy for enhancing rural flood and drought management not only aligns with ecological principles but also makes prudent economic sense by optimizing resource allocation, minimizing financial burdens, and promoting long-term sustainability.

2. NbS designed to meet the core challenges of floods and droughts also have substantial co-benefits, which in some cases exceed the core objectives of the investments. NbS can offer multiple co-benefits in rural environments beyond flood and drought management, such as carbon sequestration, enhanced biodiversity, fisheries production and the provision of Non-Timber Forest Products (NTFPs), which can further contribute to community livelihoods. By addressing multiple challenges simultaneously, NbS contribute to a more holistic and sustainable paradigm, where positive outcomes can be realised across interconnected systems. This integrated approach is particularly valuable in resource-constrained contexts, offering cost-efficient solutions that optimize the allocation of limited resources.

1 Outcome 2.1: Strengthened urban flood and drought resilience through innovative climate-sensitive and ecosystem-based planning tools and adaptation interventions;
Outcome 2.2: Strengthened rural flood and drought resilience through ecosystem-based planning tools and adaptation interventions;
Outcome 2.3: Rehabilitated basin headwaters and wetlands, to improve water security and climate resilience through ecosystem-based adaptation interventions.

These NbS approaches will illustrate how NbS can be implemented within the national and regional context, to build skills and understanding around NbS and to demonstrate their efficacy in addressing the challenges of floods and droughts in the 9C-9T sub-basin.

As part of the development of the NbS demonstration projects, an assessment of the economic performance of NbS and hybrid measures was commissioned to (i) establish the economic benefits of nature-based solutions for flood and drought resilience; (ii) provide a rough order of magnitude estimate of the economic value of the proposed NbS measures in the three landscapes; and (iii) highlight the economic case for investment in NbS approaches. The economic analyses were developed in cooperation with the Economics of Land Degradation (ELD) Initiative, hosted by GIZ.

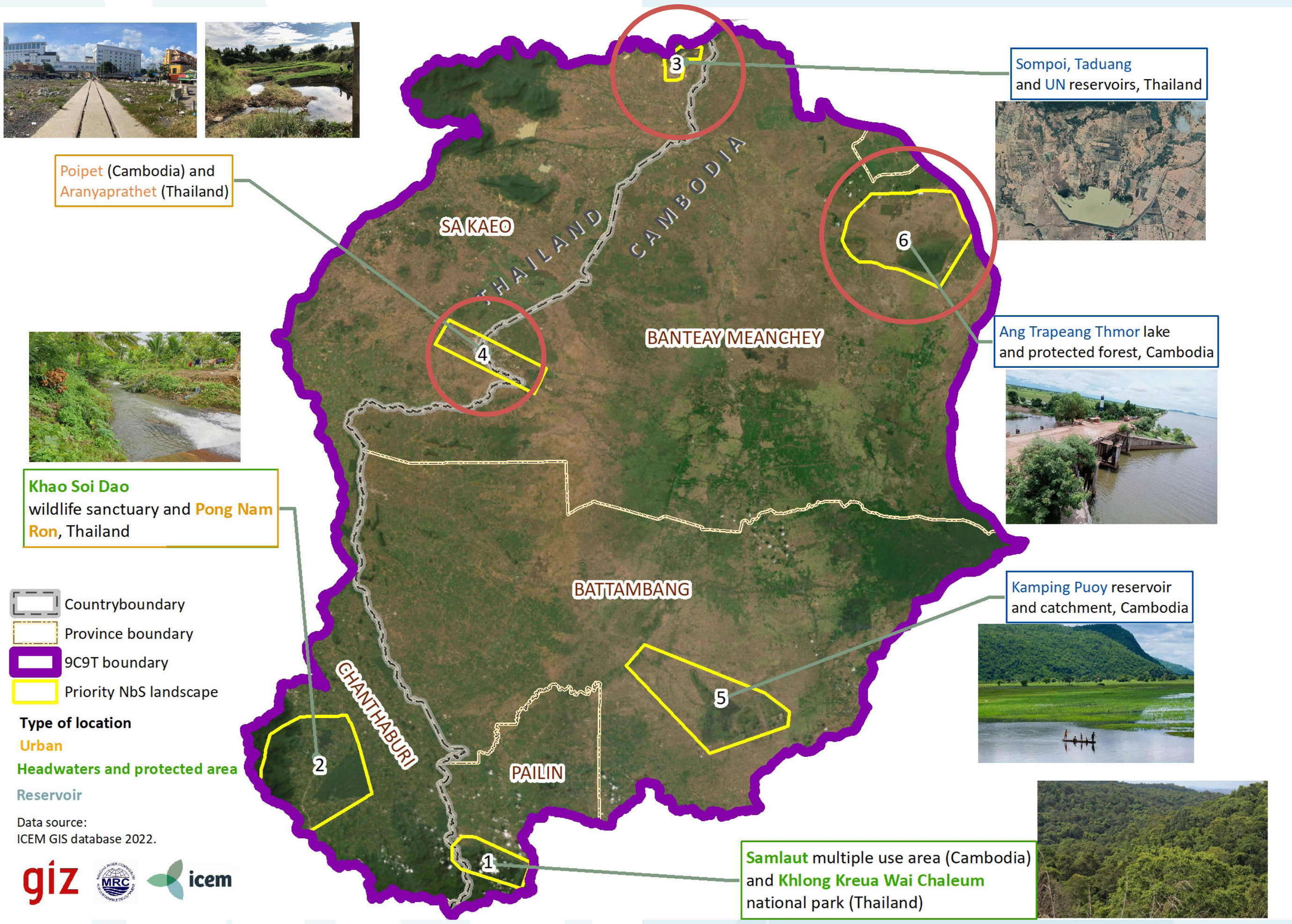
This policy brief provides a summary of the economic assessment and demonstrates the economic benefits of the rural NbS measures proposed at Ang Trapeang Thmor (ATT) reservoir, Cambodia and Sompoi reservoir, Thailand, to support the mainstreaming of findings into policy, planning and practice (Figure 1). The economic analysis of NbS in an urban context are presented in a separate policy brief.

3. NbS interventions will require coordination of investments across sectors, administrative and national boundaries. The river basin's natural resources that support rural environments, such as forests, rivers, wetlands, and aquatic ecosystems, are interconnected and do not adhere to political boundaries. Looking at the transboundary landscape perspective, as shown in Figure 2, the proposed interventions and flood management approaches in Sompoi will have a positive impact downstream on the 9C catchment in Cambodia and jointly with the ATT intervention further down till the Tonle Sap. Successful NbS implementation requires recognizing these shared resources and jointly managing them. Coordinated investments in NbS necessitate integrating the interests and perspectives of different countries and sectors.

4. In the case of rural catchments in particular, a payment for ecosystem services schemes could increase significantly the economic benefit of the measures. This would both incentivise protection measures and return financial resources to communities in the basin. This will also require institutional arrangements to ensure effective monitoring of forest areas and dispersal of funds to affected communities.

5. While some benefits of NbS result in immediate and tangible financial gains like the provision of additional irrigation ponds or the prevention of financial losses from flood damages, certain benefits, like carbon sequestration, may not yield immediate financial benefits. Successful afforestation measures for example will require effective monitoring and enforcement mechanisms and need the creation of specific institutions to allow potential economic benefits to be realised as a financial gain and returned to communities in the basin.

Figure 1: The 9C-9T sub-basin and proposed NbS projects, including those selected for economic analyses (3 – Sompoi and 6 – Ang Trapeang Thmor)



Geographical, environmental and socio-economic context

The 9C-9T sub-basin is on the West of the Lower Mekong Basin, stretching across the border between Thailand and Cambodia. The sub-basin covers an area of 14,952 km^2. Most of the basin lies in Cambodia, where it is known as the Stung Mongkol Borey basin, covering 10,866 km^2, or 72.7% of the total area. The remaining 27.3% of the sub-basin lies in Thailand, where it is referred to as the Tonle Sap basin (Figure 3).

The 9C-9T sub-basin is of significant ecological importance to the Lower Mekong Basin, containing forests, wetlands, and rivers supporting important ecosystem services and aquatic biodiversity, particularly in the Tonle Sap Lake. The sub-basin is an important contributor to sustaining ecosystem services and aquatic biodiversity in the Tonle Sap Lake, as well as providing terrestrial and aquatic transboundary wildlife corridors. Their effective rehabilitation and maintenance are of critical concern to Thailand and for Cambodia downstream.

In rural areas agricultural employment remains the predominant source of household income, with most residents within the catchment engaged in livelihoods related to agriculture. The region is one of the top producers of rice, maize and cassava. Tourism including the attraction of natural areas, natural parks and cultural heritage sites is another important foundation of the economy in both countries. Despite rapid economic development in recent years, poverty remains relatively high. Estimates for 2015, suggest that around 15% of the population in the 9C basin are below the national poverty line and figures from 2017 indicate that between 15-20% of the population in the 9T fell below the poverty line.

6. Additional planning and design work should be pursued as part of an integrated spatial plan. This will be critical to maximize the benefits of NbS which typically perform best at scale. In the rural catchments, this should be part of an integrated land use and integrated water resource management (IWRM) plan. This is likely to include elements such as the development of suitable cost norms for NbS measures and capacity development to raise awareness of NbS concepts, measures and their applicability in different contexts.

7. Due to data availability limitations and resource constraints estimates generated in the economic assessment are best regarded as rough order of magnitude estimates, to be used to provide a preliminary understanding of the scale and feasibility of the project before more detailed analysis and cost estimation can be conducted. The study findings have been affected by a lack of data, particularly relating to the hydrology and water balance of the reservoir landscapes, including the absence of sufficient data to allow an assessment of the impacts of flash-flooding at Sompoi. This analytical study suggests that further investment in more detailed appropriate pre-feasibility studies is necessary. With the ongoing development of the project and further collection of good-quality and reliable data the economic assessment can be optimized to better inform concrete investments. Also, hydrological modelling resources are an important means of benefit quantification and need to be an integral part of future studies.

8. There is also a need to better integrate the impacts of climate change into the hydrological and sedimentological analysis, to understand what this will mean for the watersheds over the next thirty years. Climate change is expected to cause more intense rainfall events exasperating issues with erosion, sedimentation and flooding, at the same time rainfall variability is expected to increase causing issues for crop production, and increased temperatures are expected to negatively affect crop production and human health. At present this is absent from the economic analysis due to data and resource constraints, but it is crucial to be considered in any follow-up activities.

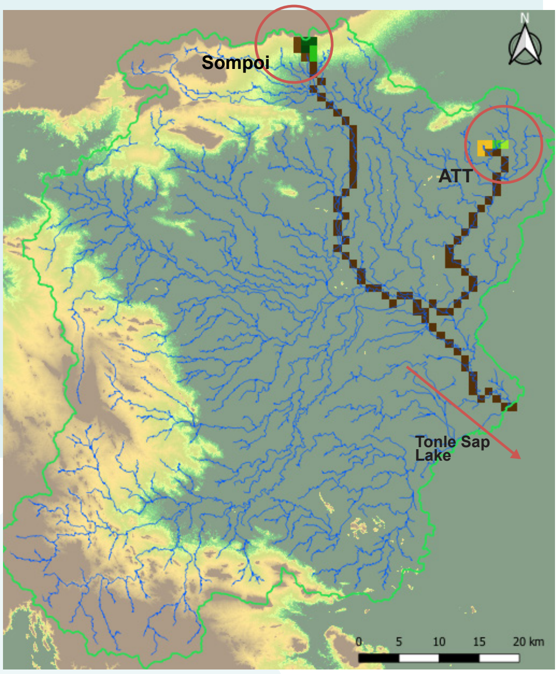


Figure 2: Transboundary hydrology and sediment linkages across rural landscapes

Figure 3: The 9C-9T sub-basin in the Lower Mekong Basin

Key environmental challenges in the 9C-9T sub-basin

The 9C-9T sub-basin, while ecologically significant, has suffered substantial environmental degradation over the last 30 years. The expansion of land use for agriculture has led to loss of the areas once extensive forests as well as considerable loss of wetland areas. Based upon field observations and stakeholder reports, the loss of forest cover and wetlands has affected the hydrological functioning of the catchment, increasing flood risks, decreasing water availability in the dry season as well as leading to issues with soil-loss, water quality and increased sedimentation in water bodies. At the same time, agricultural practices including the expansion of fertilizer and chemical use and the cultivation of sloping land for cash crops, have further affected water quality and erosion.

The impacts of climate change are expected to compound these challenges. Climate projections for the 9C-9T[2] demonstrates variable rainfall in the wet season, while in the dry season increased temperatures at both ATT and Sompoi are anticipated to have impacts on human health and agricultural productivity. Climate change is also expected to result in increased variability of weather, leading to increased risks of both extreme rainfall events and flooding, and also prolonged periods without rainfall and water shortages. Increased variability of rainfall, particularly at the start/end of the wet season, is likely to damage crop production dependent on rainfall.

The importance of nature-based solutions for flood and drought management

The benefits of healthy ecosystems for flood and drought resilience and security in water supply and quality are being lost in both countries upstream and downstream. There is little on the ground investment in restoration of watersheds within the 9C-9T sub-basin or neighbouring areas. Most investment goes to conventional infrastructure solutions such as reservoirs, irrigation systems, dams and transport infrastructure, which in turn suffer from increasing watershed erosion, sedimentation and flood damage.

Establishing a network of nature-based measures in priority landscapes will contribute to reducing flood and drought risk, to strengthen hard infrastructure resilience, ecological integrity and connectivity, the management and improvement of water quality, the conservation of water resources, and to the restoration of watersheds and degraded forests. The overall goal is to demonstrate measures that can be replicated, upscaled and rolled out across the basin's agricultural and headwaters landscapes, as a connected network so that their cumulative impact will substantially reduce the risks of flood and drought.

NbS serve to manage, restore, and create natural features, in the case of this highly degraded catchment, reinstating lost ecosystem services, and thereby providing services equivalent to those offered by grey infrastructure, for example by providing natural water storage to mitigate flood and drought events. NbS also provide a range of additional services that are difficult to supply though conventional means, such as in rural areas erosion control, habitat improvement and carbon sequestration.

A cost-benefit analysis (CBA) decision support framework has been applied for this study. CBA estimates the societal net benefits (core and co-benefits) of NbS options in financial terms. In order to evaluate different investment options, investigate their performance under different conditions, and enable the attribution of benefits to NbS interventions, two scenarios were developed – the business as usual (BAU) and NbS scenarios. These scenarios were assessed as part of the study:

- **Business as usual (BAU) scenario –** in this study, this is represented by the baseline scenario (without the project/NbS interventions); and
- **NbS scenario –** as the project is still at the conceptual stage, this has largely been based on landscape scale spatial mapping of proposed NbS interventions and discrete hydrological modelling.

The scenario development involved the identification of likely impacts of NbS interventions, identification of the most significant impacts and identifying a means of quantifying impacts. The approach focused on three target landscapes, including (i) two reservoir catchment landscapes in Cambodia and Thailand and (ii) a transboundary urban landscape. In the case in question for the transboundary rural areas, the scenarios were as follows:

- **Ang Trapeang Thmor** (Cambodia) – hydrological and sediment modelling based upon GIS analysis with and without NbS interventions; and
- **Sompoi** (Thailand) – hydrological and sediment modelling based upon GIS analysis with and without NbS interventions.

Under this study, the valuation was limited to major core benefits (e.g. water availability) and important co-benefits (e.g. carbon sequestration, fisheries production). Costs of proposed interventions included investment costs (CAPEX), operation and maintenance costs (OPEX) and opportunity costs, for (i) forest rehabilitation and reforestation; (ii) tree planting and restoration of natural channel buffers; (iii) construction of decentralised irrigation/fish ponds; and (iv) tree planting and restoration of agricultural field edge buffers. For ATT this also included tree planting and restoration for the flooded forest and Plong grassland.

2 *9C-9T Basin Atlas – flood and drought management in Cambodia and Thailand. Climate projections -* [*https://9c9t.mrcmekong.org/*](https://9c9t.mrcmekong.org/)

NbS benefits were established based upon quantified impacts modelled in the previous step, through estimates of impacts on system productivity and through transfer pricing from evaluation of similar benefit streams, including for co-benefits. The core benefits focused on (i) sediment reduction; (ii) maintaining water storage in the reservoir; (iii) decentralised dry season irrigation. Co-benefits focused on (i) increased fish stocks in ATT irrigation ponds; (ii) non-timber forest products (NTFPs); and (iii) carbon sequestration. Some hydrological and sedimentological modelling was conducted for the reservoirs to allow the quantification of core benefit streams. Climate change impact was not evaluated.

The CBA was conducted over a 30-year time horizon reflecting the long-term nature of investments in NbS. A base-case discount rate of 9% was adopted in line with typical investment projects in the region. Sensitivity analysis was conducted for the results to test the robustness of the analysis, and reflect substantial uncertainties surrounding estimates of costs and benefits, as well as highlighting the effect of differing discount rate assumptions.

The overall methodological process for the study is presented in Figure 4.

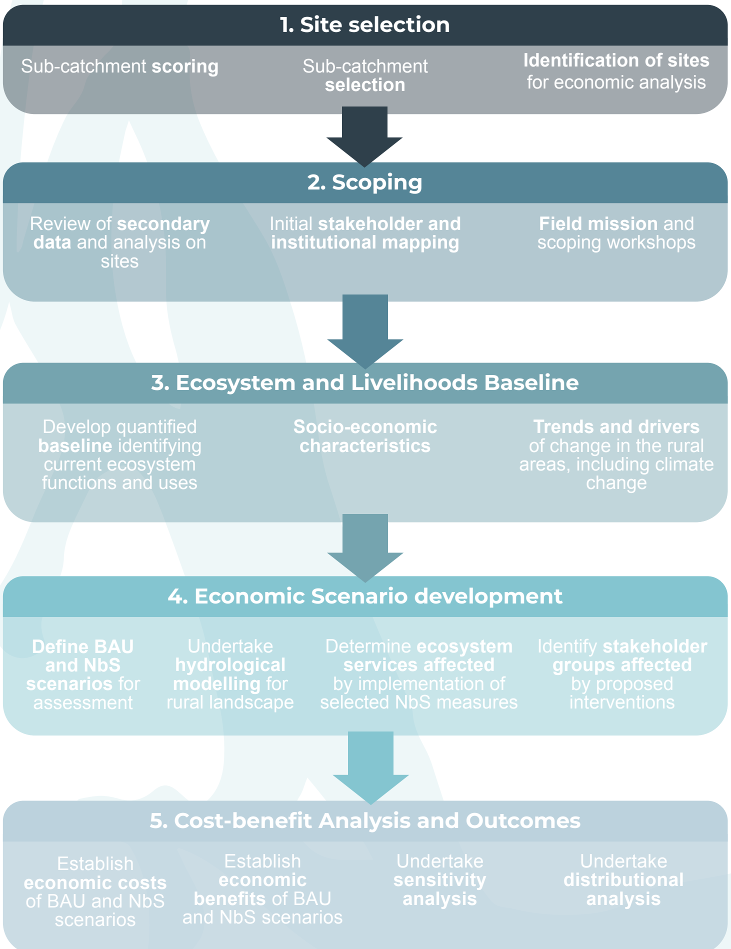


Figure 4: 9C-9T study methodological approach

COST-BENEFIT ANALYSES OF NATURE-BASED SOLUTIONS

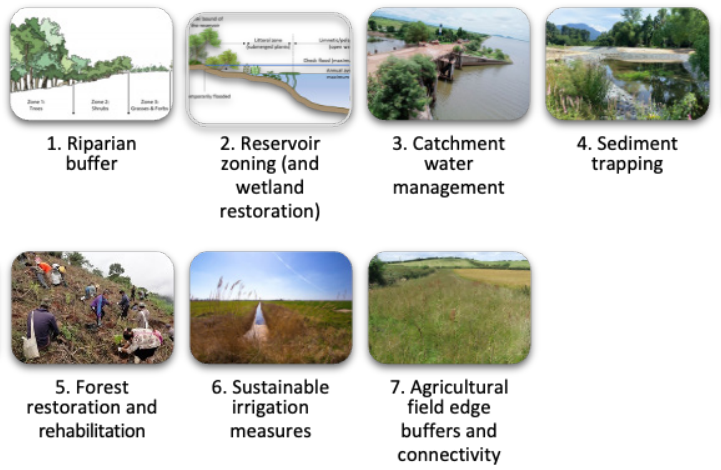
Proposed nature-based solution concepts and their expected benefits

A range of NbS measures have been designed for the 9C-9T sub-basin. In ATT and Sompoi, NbS measures selected for economic valuation consisted of riparian buffer strips along channels; forest reforestation and rehabilitation; the provision of decentralised irrigation/fish ponds in the upper catchment of existing large water storage reservoirs; and agricultural field edge buffer strips and Plong grassland area (Figure 5). At ATT, this also included the restoration of the flooded forest and Plong grassland area. The project objectives address water management concerns by focusing on:

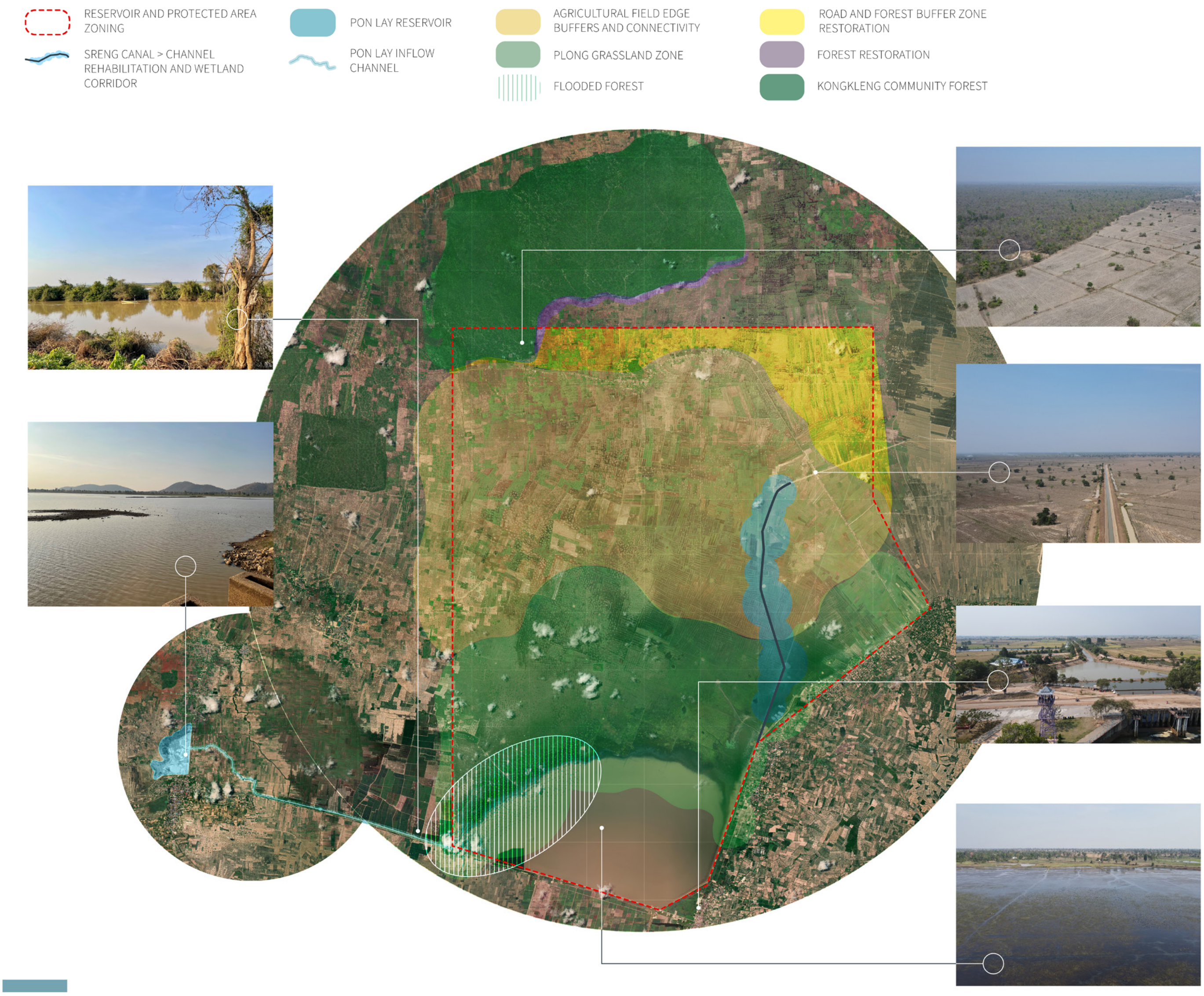
- Sediment management and watershed rehabilitation
- Establishing a network of irrigation/fish ponds and the restoration of drainage channels and riparian buffers;
- Protected area restoration and management, forest restoration and biodiversity safeguards; and
- Wetland restoration, reservoir zoning and water management.

These measures targeted reductions in run-off and soil loss in agricultural areas and erosion more generally, which in turn would reduce sedimentation in water bodies, extending the operating life and reducing maintenance costs for reservoirs and drainage channels.

Figure 5: Proposed NbS measures at ATT and Sompoi



ATT RESERVOIR



SOMPOI RESERVOIR

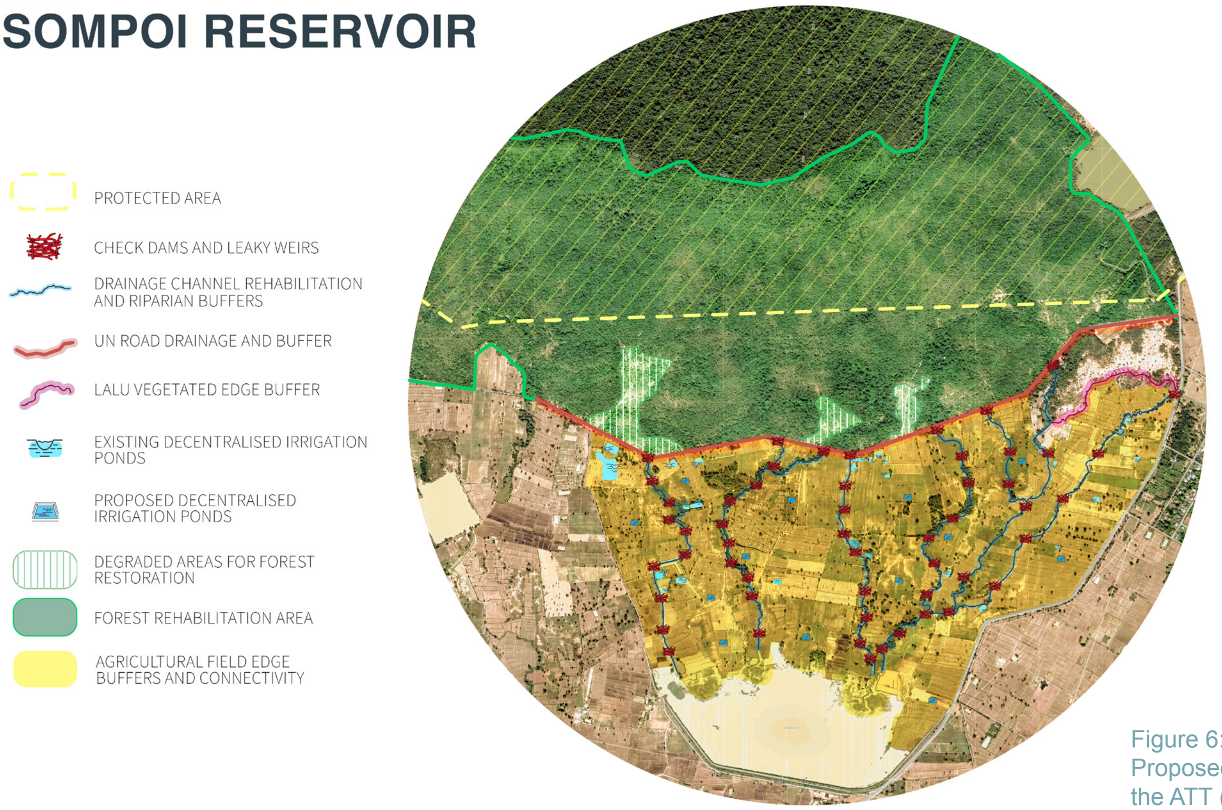


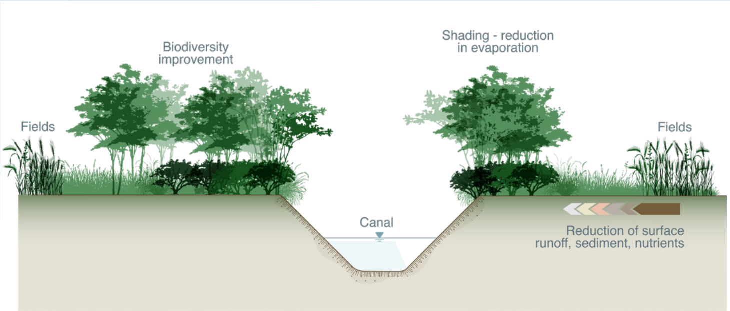
Figure 6:
Proposed project concept for the ATT (top) and Sompoi (bottom) landscapes

Example NbS measures for ATT and Sompoi – (i) forest restoration and rehabilitation and (ii) the restoration of riparian buffers

This NbS measure involves the rehabilitation of forests within the national park and its buffer zone upstream of the reservoirs, in addition to vegetating buffer strips either side of the main riparian corridors leading to the reservoirs.

Rehabilitation and restoration of forest and grasslands within the protected area will provide ecosystem services like erosion control and water regulation through improved natural water retention and is therefore mitigating flood and drought risks downstream. Forest restoration is to restore a degraded forest to its original state – that is, to re-establish the presumed structure, productivity and species diversity of the forest originally present at a site. The purpose of forest rehabilitation is to restore the capacity of degraded forest land to deliver forest products and services. Within both ATT and Sompoi, opportunities exist for developing nodes, stepping stones and corridor networks of forests (within national parks and community forests). Forest restoration and rehabilitation will be implemented on sites where forest loss has caused a decline in the quality of ecosystem services, including those for the downstream reservoirs, agricultural land and roads.

Riparian vegetated buffer strips along drainage channels, canals, reservoirs and field edges will also serve to reduce soil erosion, reduce evaporation, improve water quality and help nutrient retention in soils. This fundamentally reduces sedimentation in the reservoirs, improving water availability. The buffer strips also provide other co-benefits such as carbon sequestration and enhanced biodiversity. Buffer widths should ensure the maintenance of ecological functions and biodiversity conservation. A number of core zones within the buffer area serve to fulfil this function and resilience.



Economic evaluation of proposed nature-based solution measures

Economic evaluation of the proposed measures was undertaken to demonstrate the economic benefits of the NbS measures, as well as to build a case for the more systematic consideration of NbS in policy making and planning. The proposed NbS measures are at early stages of conceptual design, so it was not possible to consider the full range of benefits offered by the proposed schemes. Figure 7 highlights the benefits that were considered and their distribution across public and private sectors.

Figure 7: Private and public, core and co-benefits considered

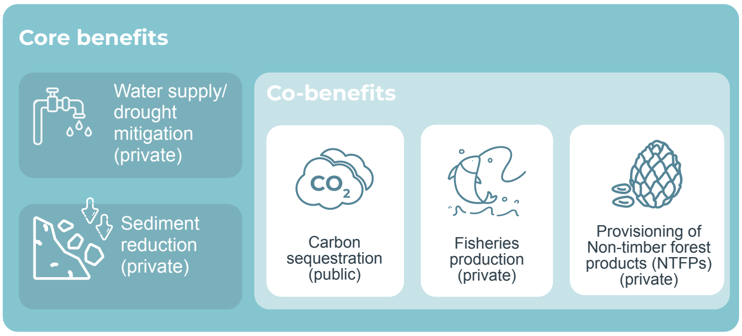
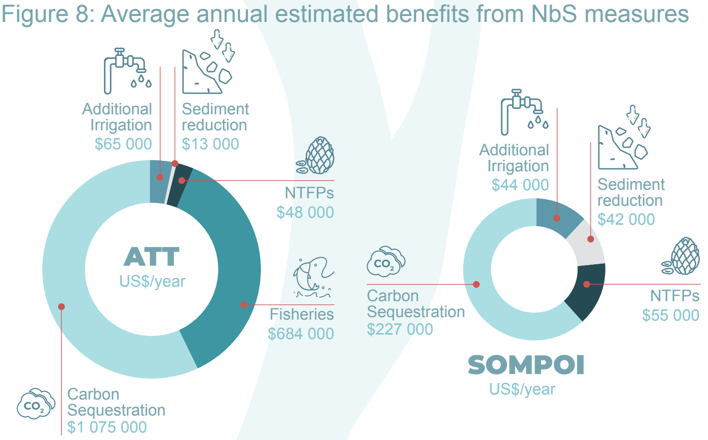


Figure 8 summarises the average annual benefits expected for the NbS measures for the rural areas. At ATT and Sompoi, additional carbon sequestration from buffer strips and reforestation was the largest benefit, and provisioning products from additional forest area. Increased fisheries from fish ponds at ATT was also an important benefit.[3] The core benefits of sediment reduction and additional irrigation while significant, were valued to be substantially lower than the co-benefits of carbon sequestration and fisheries.

In rural areas, the communities most likely to be adversely affected by NbS in the upper parts of the watersheds are those currently making unsustainable use of forest resources, such as clearing forest land for charcoal or agricultural use, or households grazing cattle in these areas, which would face restrictions on these activities. In contrast, aside from loss of crop land for the provision of retention basins and riparian corridors rice farmers and their communities in the middle and lower areas of the two rural landscapes benefit from the NbS measures. This includes benefits from greater water availability for dry season crops and improved fisheries. These benefits could be increase by facilitating the harvest of non-timber products from restored forests and buffer strips. In this context, it is important to note that while in principle carbon sequestration benefits are large, this is a measure of global environmental benefits. Allowing local communities to benefit from carbon sequestration services will require significant institutional development and engagement in carbon markets.

3 *Fish catch form the ponds where only considered at the ATT reservoir, where backwater from the reservoir temporary flood the upper agricultural area and thereby bring seasonally fish larvae from the reservoir into the ponds.*

Figure 8: Average annual estimated benefits from NbS measures



While Figure 8 gives the estimated average annual benefits, Figure 9 demonstrates how these are expected to develop over the lifespan of the project. The projects were evaluated over the expected economic life of the projects of 30 years from 2024. NbS interventions benefits typically take time to develop as restored or recreated ecological functions develop over a number of years. In the case of the ATT and Sompoi projects, full benefits grow until approximately 15 years after commissioning when full forestry benefits are realised.

Figure 9: ATT and Sompoi net benefits from NbS measures over time

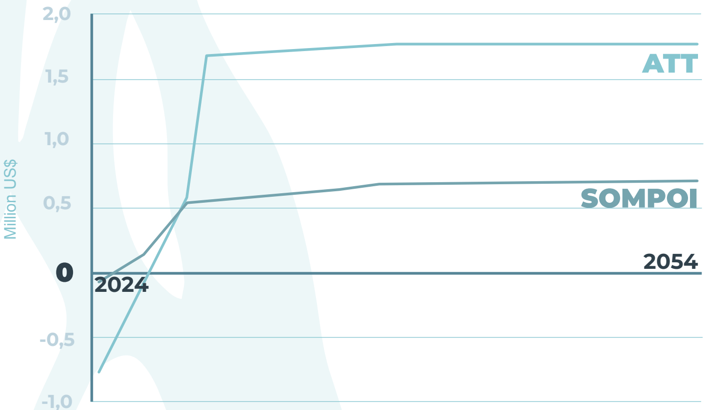
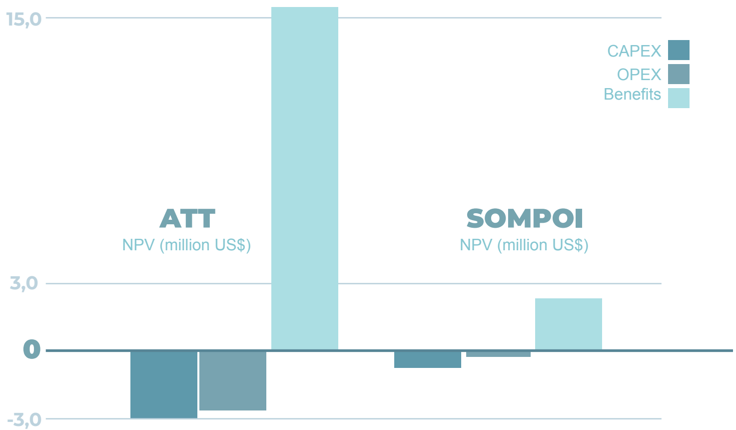


Figure 10 illustrates the overall outcome of the CBA for NbS measures in ATT and Sompoi. In both cases, the NbS measures are expected to perform well. In the ATT landscape the base case shows a net present value (NPV) (i.e. the current discounted value of the benefits minus costs over the lifetime of the project) of US$ 10.6 million and a ratio of benefits to costs (BC ration) of 2.59. To address the high level of uncertainty in the analysis, sensitivity analysis was conducted to test the results of the analysis in respect of changes in key parameters including increases in investment costs for NbS measures, increases in O&M costs for the proposed measures and, reductions in the level of benefits. In all sensitivity cases considered, NPV is at least US$ 1.7 million and the BC ratio at least 1.43 (in the most extreme case of a reduction in benefits of 50%)[4]. This is without taking account of any benefits from biodiversity that may be attributable to the interventions.

Similarly, in the Sompoi landscape, proposed NbS investments in the base case have an NPV exceeding US$ 1.9 million, albeit with a higher BC ratio of 3.73. Sensitivity analysis also demonstrates that the positive performance is generally robust to most changes in valuation parameters, again even in the most extreme case considered, with a 50% reduction in project benefits the NPV is still US$ 300,000 and the BC ratio is 1.86.

Figure 10: Summary of CBA results showing CAPEX, OPEX and benefits



4 Investment projects are generally regarded as viable if the base case ratio exceeds 1, i.e. if total discounted benefit streams exceed total discounted costs. Although thresholds for investment can be lower than 1 in some contexts.

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