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TRANSBOUNDARY URBAN LANDSCAPE

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 cities of Poipet and Aranyaprathet

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 2). 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, particularly in urban areas where core flood reduction benefits associated with river rehabilitation and urban greening are anticipated to be large. 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 effectively demonstrates that prioritizing NbS as a strategy for enhancing urban 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 urban environments beyond flood management, such as improved air quality and temperature, enhanced recreational opportunities, which can further contribute to cost savings and community well-being. 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 urban NbS measures proposed at Poipet, Cambodia and Aranyaprathet, Thailand, to support the mainstreaming of findings into policy, planning and practice (Figure 2). The economic analysis of NbS in a rural context are presented in a separate policy brief.

Geographical, environmental and socio-economic context

The 9C-9T sub-basin is on the West of the 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 1).

The 9C-9T sub-basin is of significant ecological importance to the 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.

Rapid socio-economic change in the 9C-9T sub-basin has seen the rapid expansion of urban areas. This has been particularly marked in the cross-border urban conurbation of Aranyaprathet in Thailand and Poipet in Cambodia, which are home to the two Special Economic Zones (SEZs). The border cross is also an important transport corridor between the urban centres of eastern Thailand and western Cambodia. 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.[2]

3. NbS interventions will require co-ordination of investments across sectors, administrative and national boundaries. The river basin's natural resources that support urban environments, such as rivers, wetlands, and aquatic ecosystems, are interconnected and do not adhere to political boundaries. From a transboundary landscape perspective, the proposed interventions and flood management approaches in Aranyaprathet will have a positive impact downstream in Poipet. 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 urban areas, NbS measures should also be considered systematically as part of the planning process. Urban governance challenges often revolve around land use planning, planning controls and enforcement to set side, protect and enhance green areas in the rapidly developing urban areas. At the same time there is a strong case for more effective property taxation to allow more of the benefits of public interventions and investments (such as NbS) to be captured by municipal authorities, so enabling the sustainable management and further development of NbS approaches.

5. While some benefits of NbS result in immediate and tangible financial gains or prevention of financial losses, certain benefits, like carbon sequestration, may not yield immediate economic benefits. They need the creation of specific institutions to allow potential benefits to be returned to communities in the basin.

6. 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 a project, before more detailed analysis and cost estimation can be conducted. The study findings have been affected by a lack of data in urban environments, particularly relating to hydrology (e.g. flood modelling and water balance), including the absence of sufficient data to allow an assessment of the impacts of fluvial flooding in Aranyaprathet. If further investments are to be considered for Poipet and Aranyaprathet, good-quality and reliable data is required.

7. There is also a need to better integrate the impacts of climate change into the hydrological analysis to understand what this will mean for the watersheds over the next thirty years. At present this is absent from the economic analysis due to data and resource constraints, but it will need to be considered in any follow-up activities. In urban areas more intense rainfall events are likely to exasperate current issues with both pluvial and fluvial flooding, and ambient higher temperatures are likely to severely affect urban liveability human health and cooling demand.

[2] Based upon local poverty rate data obtained from provincial authorities

Figure 1: The 9C-9T sub-basin in the Lower Mekong Basin

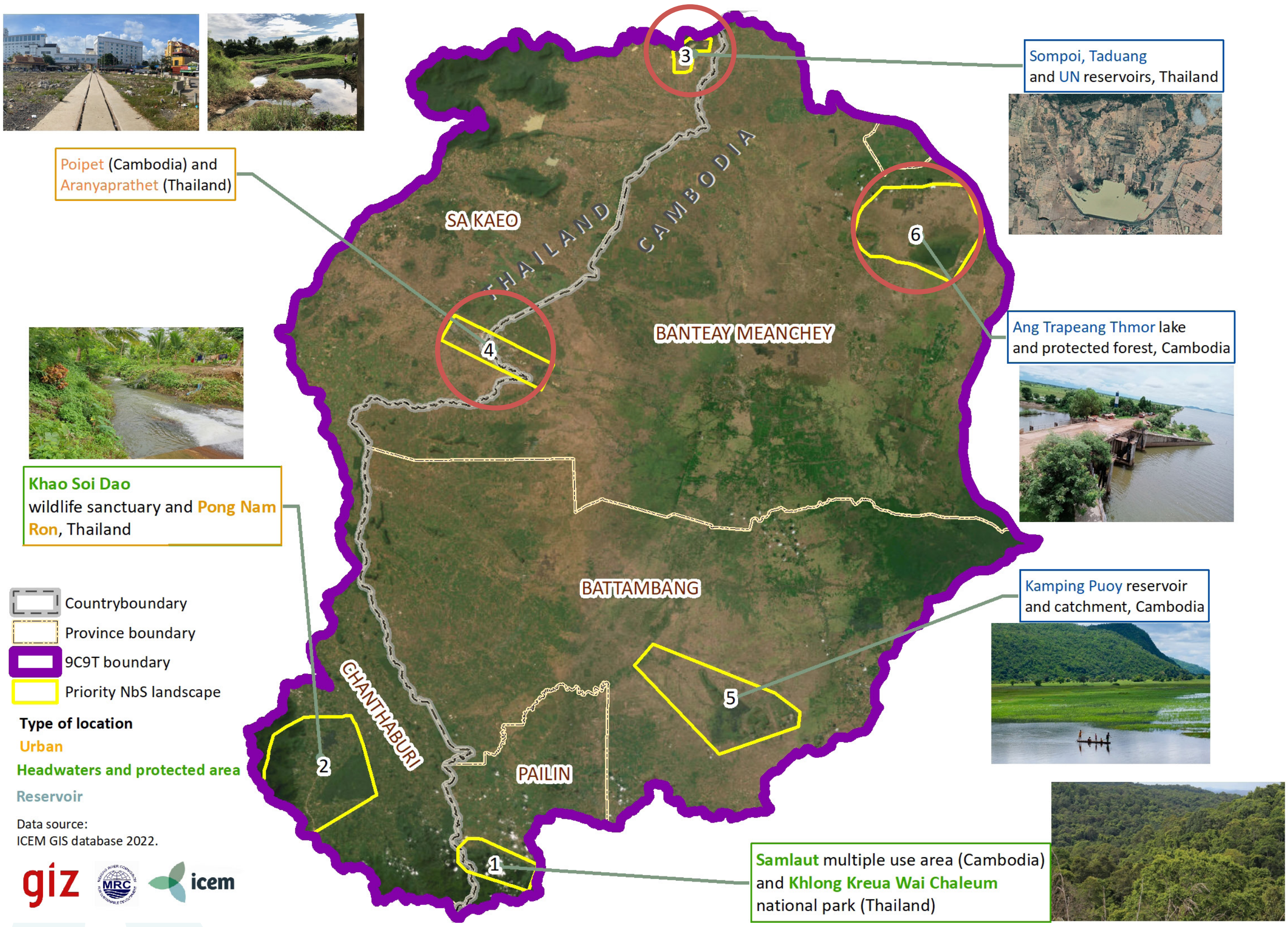


Figure 2: The 9C-9T sub-basin and proposed NbS projects, including those selected for economic analyses (3 – Sompoi and 6 – Ang Trapeang Thmor)

Key environmental challenges in the basin

The 9C-9T sub-basin, while ecologically significant, has suffered substantial environmental degradation over the last 30 years. Haphazard infrastructure development and rapid, unregulated expansion of urban areas has also brought with it a range of problems. Site visits and stakeholder consultations served to identify environmental issues in the basin including water pollution from municipal wastewater, inadequate solid waste management and urban run-off has severely polluted water close to urban areas. It was also reported that flooding exasperates water quality issues, as pollutants concentrated in water bodies during the dry seasons are widely dispersed during flood events in wet season. Urban areas have been developed without adequate drainage or consideration of flood protection.

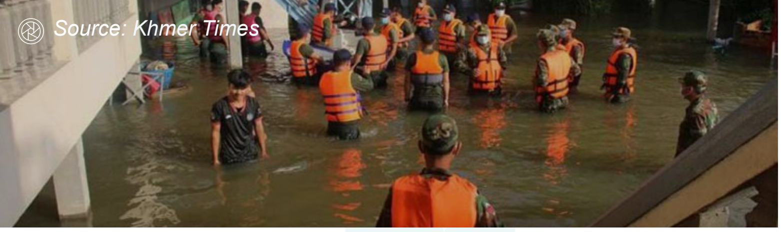
Pluvial flooding from urban run-off is an annually recurring issue in Poipet and Aranyaprathet. The increase of impermeable, sealed surfaces such as concrete has not been accompanied by adequate drainage provision, neither through the construction of storm drains nor from the provision of urban green space to allow drainage. Poipet and Aranyaprathet also suffer from regular fluvial flooding which poses a significant hazard. Lack of development controls have led to encroachment into flood prone areas and the dumping of waste in the river corridor has served to obstruct the river channel and further exasperate flooding issues. In addition, both urban areas suffer increasingly from high temperatures (compounded by urban heat island effects), air pollution and poor air quality, and a lack of public green space.

The impacts of climate change are expected to compound these challenges. Climate projections for the 9C-9T[3] demonstrate increased temperatures for Poipet and Aranyaprathet in the dry season, which are expected to have impacts on human health and agricultural productivity.[4] 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.

[3] 9C-9T Basin Atlas – flood and drought management in Cambodia and Thailand. Climate projections - https://9c9t.mrcmekong.org/

[4] See for example WHO, 2021, Building Climate Resilient Health Systems in Cambodia. Website; and Jorge Alvar-Beltrán, Riccardo Soldan, Proyuth Ly, Vang Seng, Khema Srun, Rodrigo Manzanas, Gianluca Franceschini, Ana Heureux. 2022, Climate change impacts on irrigated crops in Cambodia. Agricultural and Forest Meteorology, Volume 324.


Source: Kohsantepheap Daily



METHODOLOGICAL APPROACH

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 urban areas, the scenarios were as follows:

- **Poipet** (Cambodia) – hydrological modelling of fluvial based upon GIS analysis with and without NbS interventions; and
- **Aranyaprathet** (Thailand) – run-off modelling based upon GIS analysis with and without NbS interventions.

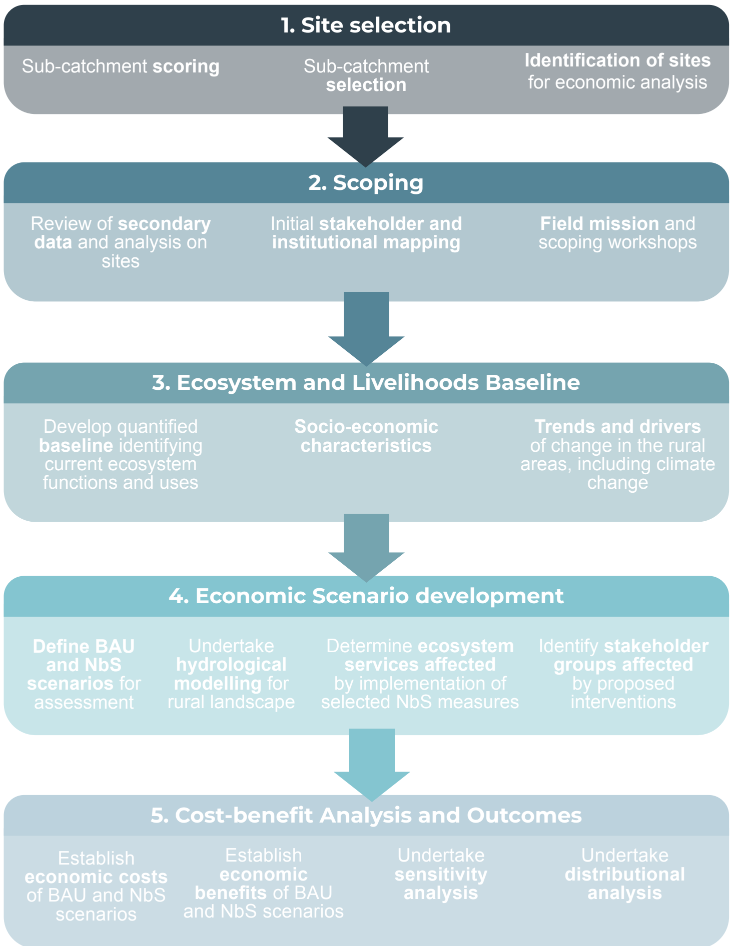
Under this study, the valuation was limited to major core benefits (e.g. flood reduction) and important co-benefits (e.g. carbon sequestration). Costs of proposed interventions included investment costs (CAPEX), operation and maintenance costs (OPEX) and opportunity costs, for (i) river channel reprofiling and bank stabilisation, (ii) floodplain rehabilitation (forest protection and tree planting); and (iii) city greening (tree planting, swales, permeable surfaces).

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 benefits focused on (i) direct flood damages avoided; (ii) indirect flood damages avoided; and (iii) city greening co-benefits (air purification, carbon sequestration, water purification). Some hydrological modelling was conducted to allow the quantification of core benefit streams. Climate change impact was not evaluated.

The cost-benefit analysis was conducted over a 30-year time horizon from 2024 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 3.

Figure 3: 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 catchment. In Poipet and Aranyaprathet, NbS measures targeted reductions in (i) fluvial flooding and (ii) pluvial flooding and run-off. The project objectives address water management concerns by focusing on:

- Cross-border stormwater management through urban greening; and
- Transboundary river restoration and rehabilitation.

It should be noted that not all of the NbS project concept measures designed to be implemented under the Master Plan for Poipet and Aranyaprathet (shown in Figure 5) were assessed as part of the economic analyses, due to data accessibility and modelling limitations. The measures considered for the economic analyses included the widening and rehabilitation of the river channel, including floodplain restoration, and river bank stabilisation and rehabilitation, as well as urban greening (tree planting) for Poipet. For Aranyaprathet, measures included the retention and infiltration of surface runoff including the development of rain gardens and green roofs, the retention and infiltration of surface runoff, through bioswales and infiltration trenches, the development of riparian buffer strips, as well as urban greening measures (Figure 5).

Figure 4: Proposed project concept for the transboundary Poipet and Aranyaprathet landscape

POIPET & ARANYAPRATHET

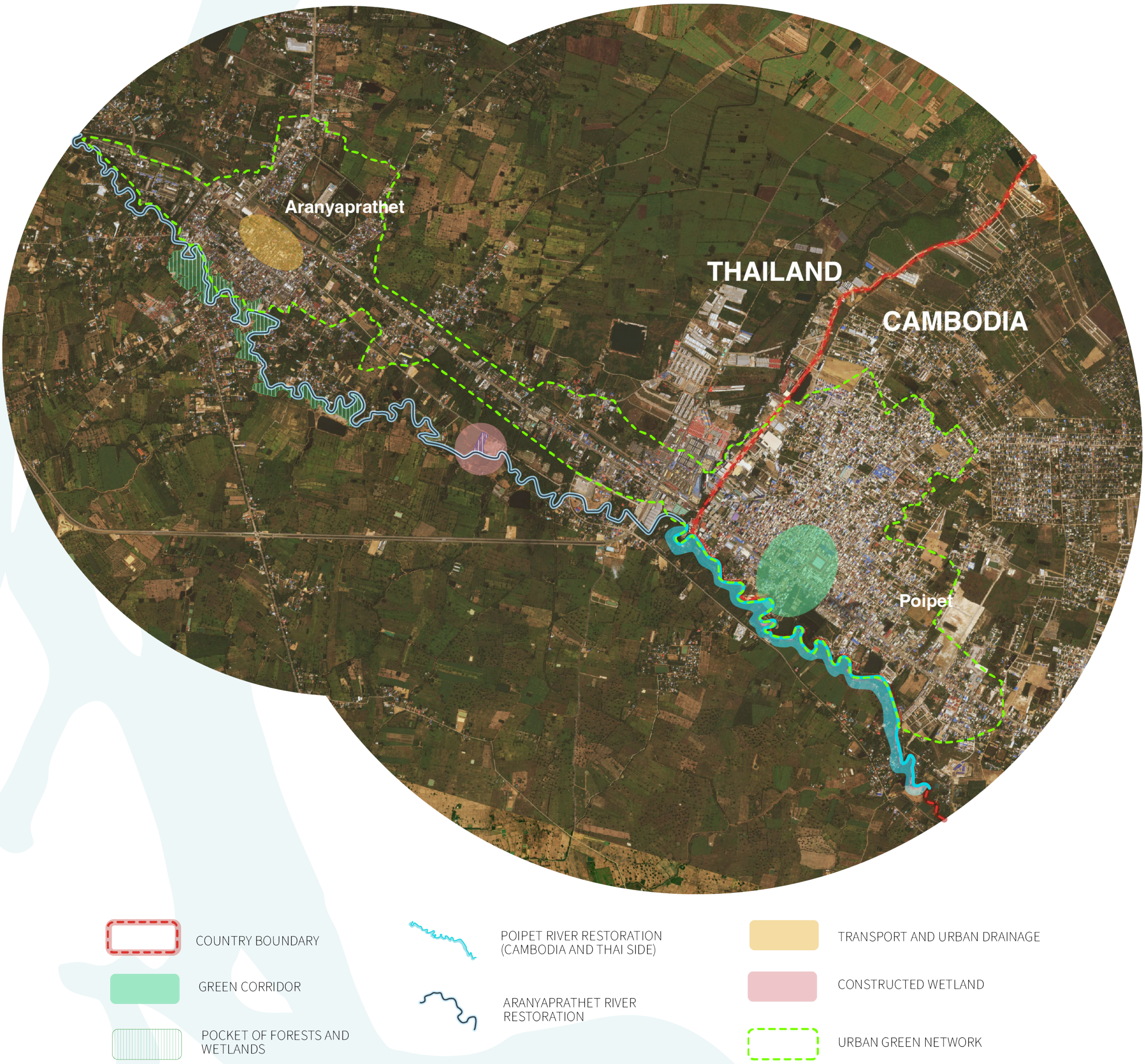


Figure 5: Proposed NbS measures in the cross-border urban landscape of Poipet and Aranyaprathet

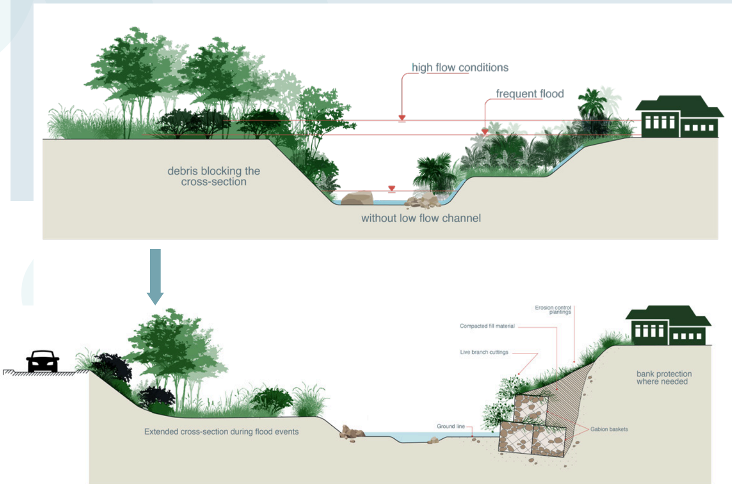
1. Retention and infiltration of rooftop runoff
2. Retention and infiltration of surface runoff
3. River channel widening and rehabilitation
4. River bank stabilization and rehabilitation
5. Riparian buffer strip
6. Urban greening

Example NbS measures for Poipet – river restoration and rehabilitation

The river linking Aranyaprathet and Poipet requires significant rehabilitation as an important component of a major flood and water quality management strategy for the towns and further downstream. River restoration and rehabilitation seeks to develop and improve the river's ecosystem health and to achieve an adequate hydrological function including sufficient flow capacity. River rehabilitation should include river widening and river bank stabilisation, embracing the development of the following:

- River cross-sections;
- River bed material;
- River bank stabilisation, including vegetated gabions;
- Mixed native plant's species for riparian buffers and wetland corridors; and
- Incorporating natural structures to diversify flow velocity and to improve the interconnectivity of the river bed surface with the immediate underground.

The starting point for river restoration and rehabilitation is to enable a natural development so that it shifts back into a virtually natural state in addition to giving the river space to increase flood retention potential. This ideal development potential must be aligned with socio-economic constraints like available space, existing illegal settlements encroaching on the river, boundary demarcation lines, protection of infrastructure corridors, land use buffers (for roads, railway, power lines, water supply and sanitation infrastructure, etc.), legally binding concessions for water abstraction and other possible restrictions. Extensive consultation is needed to discuss the potential implications of this intervention.



Economic evaluation of nature-based solution interventions

Economic evaluation of the proposed measures was undertaken to help justify proposed 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.

Core benefits include a significant reduction of flood risk post-implementation of channel and bank rehabilitation and a reduction in runoff and excess drainage, through a network of decentralized urban rainwater retention measures. The groundwater recharge during rain events through the implemented greening measures also benefit the mitigation of drought events, highlighting multipurpose function of NbS. Co-benefits are expected to include reduction in ambient air temperatures, improvements in air quality and carbon sequestration, and greatly improved urban amenity, via the rehabilitation of existing park land and the establishment of new green spaces and green corridors. Figure 6 highlights the benefits that were considered and their distribution across public and private sectors.

Figure 6: Private and public, core and co-benefits considered

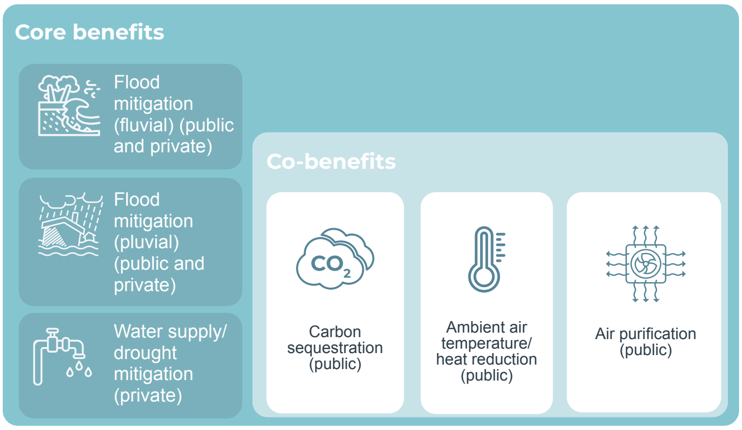
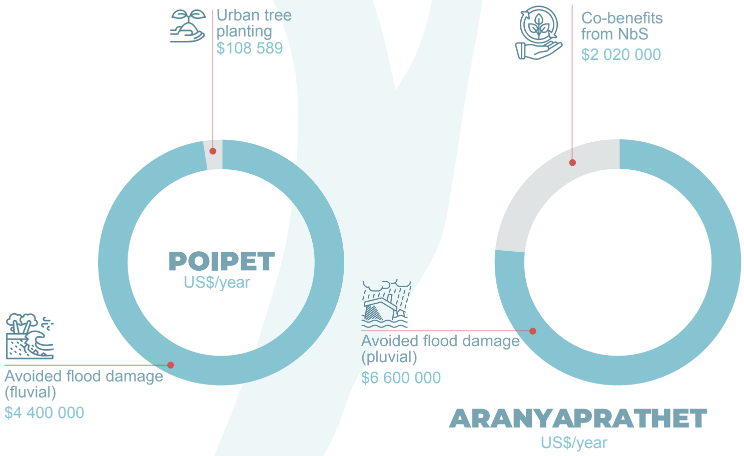


Figure 7 summarises the average annual benefits expected for the NbS measures for the urban areas. In Poipet and Aranyaprathet, while co-benefits remained important, the largest benefits were the significant avoided fluvial and pluvial flood damages in the urban areas.

In the case for Poipet, the evaluation focussed upon the value of avoided damages from fluvial flooding to which most of the benefits are attributable, along with some more minor benefits associated with avoided flood damages from pluvial flooding via urban tree planting (reduced run-off, carbon sequestration, air purification, ambient temperature reduction). In the case of Aranyaprathet, only avoided flood damages from pluvial flooding were assessed, along with the amenity value of additional green space, and, similar to the Poipet case, the benefits of urban trees. In urban areas, significant benefits are expected to be realised for urban residents through reduced flooding and urban greening benefits. These will be available to all residents. On one hand, poorer households, without access to adequate private space or effective cooling, are likely to benefit significantly from the improvement of public spaces which they can enjoy freely.

Figure 7: Average annual estimated benefits from NbS measures



While Figure 7 gives the estimated average annual benefits, Figure 8 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. NbS interventions benefits typically take time to develop as restored or recreated ecological functions develop over a number of years. In the cases of Poipet and Aranyaprathet, benefits from flood mitigation are available immediately after project completion. The growth of benefits over time largely reflects expected growth in avoided flood damages.

Figure 8: Aranyaprathet and Poipet net benefits from NbS measures over time

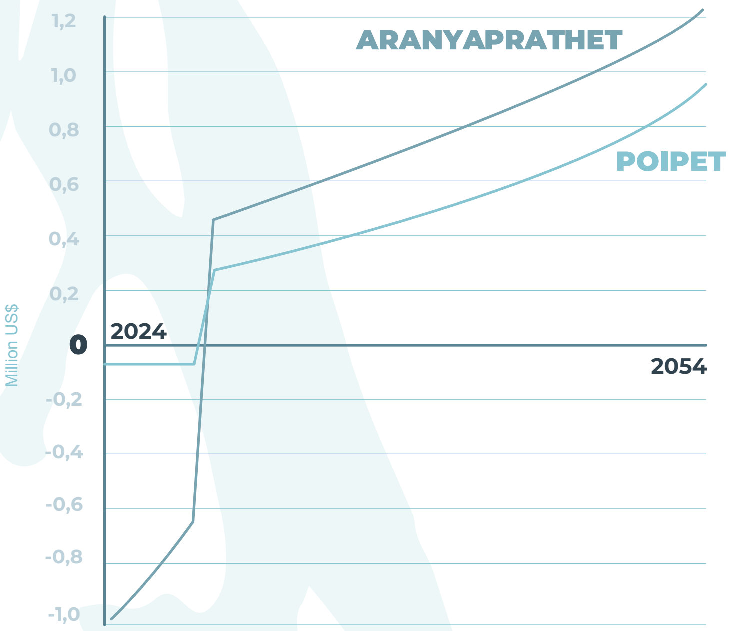
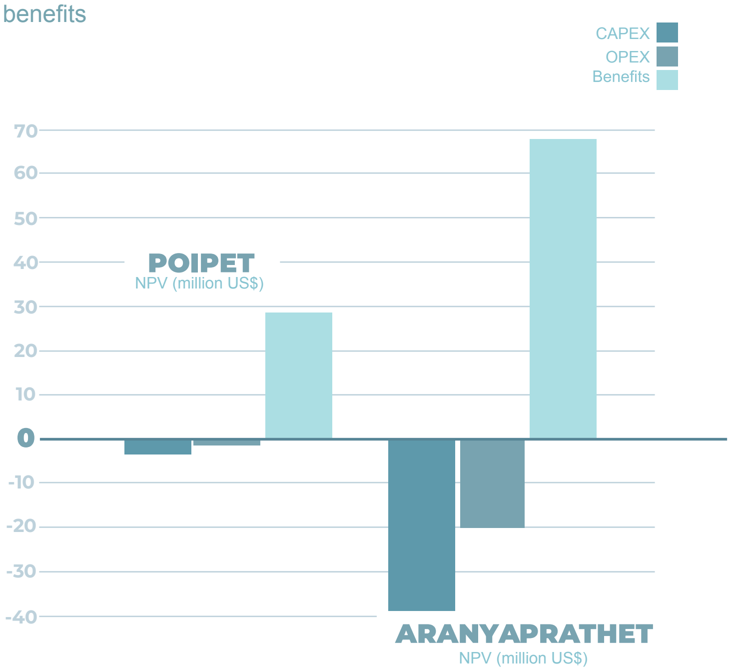


Figure 9 illustrates the overall outcome of the CBA for NbS measures in Poipet and Aranyaprathet. In both cases, the NbS measures are expected to perform well, with a ratio of benefits to costs (BC ratio) ranging between 7.98 in Poipet to 1.17 in Aranyaprathet.[5] In the case of the lower BC ratio in Aranyaprathet, the project still has a substantial net present value of US$ 9.7 million.

The proposed nature-based stormwater management interventions in Aranyaprathet have relatively high estimated upfront cost and O&M costs, although this is to some extent off-set by larger benefits. To address the high level of uncertainty in the analysis, a sensitivity analysis was conducted for key costs and benefits, including increased investment costs, increased O&M costs, differing discount rates and decreased flood benefits. For Poipet, the economic performance remains positive in all considered sensitivity cases. Aranyaprathet, was more sensitive to increased discount rates due to large upfront costs relative to benefits spread over the economic life of the project.

Figure 9: Summary of CBA results showing CAPEX, OPEX and benefits



5 Investment projects are generally regarded as viable if the BC ratio exceeds 1, i.e. if total discounted benefit streams exceed total discounted costs. Although thresholds for investment can be lower than one in some contexts for example a CBA of flood risk reduction schemes in three European cities found BC rations of between 0.5 and 1.3 for NbS interventions. Le Coent, P., Graveline, N., Altamirano, M.A., Arfaoui, N., Benitez-Avila, C., Biffin, T., Calatrava, J., Dartee, K., Douai, A., Gnonlonfin, A. and Hérivaux, C., 2021. Is-it worth investing in NBS aiming at reducing water risks? Insights from the economic assessment of three European case studies. *Nature-Based Solutions*, 1, p.100002.

Source: CNN