CONCEPT NOTE 3

Multi-functional Water-Sensitive Park in Sam Neua Village

Related to the Area Development Plan: Project 7.1 Green Blue Area Planning

“Additional green areas at the village level, include multi-functional public parks, sports fields”

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Supported by: BORDA Laos

Bounchan Khamphilayvong

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<table>
<tr><th>#</th><th>Content</th></tr>
<tr><td>1</td><td>

TITLE

Multi-functional Water-Sensitive Park in Sam Neua Village

Related to the Area Development Plan

Project 7.1 Green Blue Area Planning

"Additional green areas at the village level, include multi-functional public parks, sports fields"

</td></tr>
<tr><td>2</td><td>

DESCRIPTION OF PROPOSED SITES

The proposed site for the "Multi-functional Water-Sensitive Park in Sam Neua Village" covers an area of approximately 2.5 ha west of the Sam Neua village urban extension area. It is located within a meander on the left side of the river Nam Xam River, bordering an important road crossing that has connected Sam Neua town to the new Sam Neua airport since 2023. The recently-filled section of the valley hosts commercial and some residential areas. On the right side of the river, government buildings are located. The park itself consists of mostly flat grass area, with shrubs and trees along the river and the slopes to the new development areas. More visual descriptions can be found in ANNEX I.

Figure 1. Map of Project Site Area

</td></tr>
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Sites (a) facing south from main airport junction road & (b) Urban development in the Nam Xam River valley, west from the park (ITT, 2023).

3

INTRODUCTION AND BACKGROUND OF PROPOSAL

Challenges and their impact, based on field visits, visual assessment of drone maps and methods described in more detail in Annex 3:

1. ***Lack of riparian zones and vegetation (C1):*** Deforestation in riparian zones and human development related activities disrupt habitat quality and reduce the quantity of vegetation species. This decline or lack of quality and quantity of species located in riparian zones can lead to increased run-off, erosion and a deterioration of water quality, wildlife habitats and the overall health of terrestrial and aquatic organisms.
2. ***Erosion (C2):*** Erosion processes are accelerated due to land use change. Riverbank erosion becomes more prevalent when riparian zones are degraded. Vegetation helps to stabilize slopes by binding soils together with their roots, reducing erosion, but when removed it leaves the soil exposed to the flowing water and is washed away. The material loss can lead to larger scale impacts.

Landslides (C2.a): Erosion leads to the loss of structural integrity of slopes. Increasing landslide hazard due to the loss of structural integrity, potentially damaging infrastructure, property and threatening human life. In areas of filled rice fields, landslides and slope failures often occur, due to the changes in soil hydrology, weakened by structure and the weight of structures built on top.

Sedimentation (C2.b): Erosion results in increased sediment loads in the river. Sedimentation in water bodies affects their depth and quality, which impacts agriculture and aquatic ecosystems.

3. ***Water pollution (C3):*** Discharge of stormwater and polluted and untreated water directly into the river leads to significant water pollution, affecting aquatic ecosystems and human health.
4. ***Illegal solid waste disposals (C4):*** Dumpsites around the site can lead to various negative impacts, including soil and water contamination, air pollution, and threats to human health. Proper planning and management of these sites are crucial to mitigate these risks and promote sustainable waste disposal practices**.**
5. **Land use changes in natural flood plains (C5):** Since 2013, ca. 62.3% of the natural valley west of the park have been filled. This is due to the lack of alternative design approaches and raises local flood hazard. It restricts accessibility and usability during the year and limits recreational space. It also endangers buildings and crops, representing a threat to local

	livelihood and human well-being. Part of this development patterns are land prices and lack of alternative economic incentives that could guide sustainable development. 6. **Drought hazard (C6):** The proposed site is in a tropical area and part of the Nam Xam watershed, that has been prone to some drought episodes. The longest and the most severe one was recorded between 2010-2015, based on agricultural drought analysis. **7. Steep topography and delicate channel structure (C7):** The largely steep slopes in the upstream watershed pose high erosion hazards, especially in combination with deforestation. Natural drainage consists mainly of smalls streams, which provides many exposure points to impact hydrology (Watershed scale - ANNEX III). ***8.* Loss of primary forest (C8):** Important areas upstream reveal a significant decrease in primary forest and related land use changes. It results in increased surface runoff which increases flood pressure on the park or can pose a threat to structures. (Watershed scale - ANNEX III). ***9.* Flood hazard (C9)** Along the upstream southwestern and northeastern valleys of Nam Xam, flooding occurs on a regular basis. Specifically, high precipitation events (large amounts in a short period of time or continuous over a long period of time) can trigger potential flood waves (Watershed scale - ANNEX III).
4	**PURPOSE** The proposed site is a good and compact example of typical challenges that Sam Neua town faces, including lack of vegetation, erosion, flooding, drought, and deforestation. It will be a pilot example of alternative development in Sam Neua's floodplain, located directly at the entrance of the town from the new airport and close to important government buildings. In combination with awareness raising in the educational facility, it holds the potential to be a blueprint to upscale further water-sensitive development upstream and in other extension areas to protect Sam Neua town and improve the livelihood and well-being of its citizens. The identified solutions reduce exposure and vulnerability to current and future natural hazards. It also aims to improve the livability for the local population and advertise Sam Neua's heritage, as well as innovative urban development that creates a pleasant environment for visitors to experience.
5	**PROJECT OBJECTIVES** **O1.** Enhance resilience to floods and droughts in Sam Neua **O2.** Enhance biodiversity in the urban landscape in Sam Neua **O3.** Reduce the risk of erosion processes in Sam Neua **O4.** Mitigate environmental and health risks (water quality and solid waste) **O5.** Promote hazard-resilient projects and construction methods **O6.** Enhance the health and human well-being of local population in Sam Neua village and its surroundings through physical, social, and cultural activities **O7.** Provide capacity building to promote Water-Sensitive Urban Design and related topics **O8.** Reduce pressure on existing and future water infrastructure **O9.** Promote cohesive and inclusive management practices **O10.** Provide examples for economic benefits aligned with sustainable land development
6	**DESCRIPTION OF THE PROJECT** A precise description of the several solutions (S) that represent the core of the project is provided as follows. **S1.1 Ecological restoration of 10-meter-wide riparian zones:** This will be a 10-meter-wide buffer strip along the river. By applying active (planting of species) and passive (protecting species) ecological restoration, several benefits will be obtained. These include an increase in

	the structure and richness of biodiversity (flora and fauna species). Additionally, there will be improved control over run-off and erosion and enhancement in water quality (O1, O2, O3). **S2.1 Riprap:** This solution would implement rocks placed along the meander south of the park area as this area is highly vulnerable to erosion. This will prevent the progression of the river meander extending towards nearby buildings. Riprap also increases environmental heterogeneity in the river and provides habitat to invertebrates (O3). **S2.2 Living-Wood Bundles:** The vegetation that grows from the bundles helps to naturally stabilize the soil. These are placed where the small stream joins the main river to provide added support to the soil as this area is more vulnerable to erosion (O2, O3). **S2.3 Living Terrace:** Planted hedgerows naturally trap sediments which over time form a terrace. The purpose is to reduce runoff velocity which results in a lower erosive force of water. These are implemented along the bank of the conjoining stream between the road and river south of the park to stabilize the banks and protect surrounding buildings (O2, O3). **S2.4 Deflecting Elements:** This solution involves placing rocks in multiple different locations along the river channel surrounding the park to help reduce flow velocity and erosion in the river. The flow variation and structures themselves also act as habitat provision (O2). **S3.1 Wastewater and Stormwater Management Plan:** Connect the wastewater network with the DEWATS and Drainage System extension area. Addressing water pollution-related challenges in the area is linked to the “Water-Sensitive Area Development Plan (WSADP)” for Sam Neua urban expansion area. **S4.1 Restore and Rehabilitate Waste Dumping Sites:** Illegal dumping sites within the park will be identified and mapped, followed by remediation measures such as soil excavation to remove contaminated soil and revegetation efforts using native plants to restore affected areas (O4, O6). **S4.2 Waste Management Plan and on-site waste disposal options**: Include the proposed site for the multi-functional park in the suggested locations subject to the extension of solid waste services and the campaigns for public awareness in the “Water-Sensitive Area Development Plan (WSADP)”, as well as provide waste disposal options within the park (O4, O6). **S5.1 Hazard-resilient adapted walking paths and surfaces:** Usability and access of dedicated flood zones are provided by stilted walkways or bridges interconnecting the park using natural building materials (e.g. bamboo), blending modern and traditional construction forms. Permeable surfaces will incorporate design elements that reduce surface runoff and promote groundwater recharge to increase drought resilience. This enhances the positive aspects that locals and visitors can experience in the mountains and green valleys of northern Laos (O 1, O5, O6, O8). **S5.2 Flood-resilient educational facility and information panels:** An on-site flood-resilient space to be used for recreational activities, awareness raising and training. The building will reflect Sam Neua’s rich heritage and knowledge about construction with natural building materials in flood plains. Elements addressed are a) the principles of WSUD, b) Sam Neua’s “WSADP” to implement them. Furthermore, c) River basin Planning **(S7),** importance of d) Biodiversity and Soil Management e) hazard resilient construction and f) alternative forest management practices like Agroforestry and Ecotourism **(S8)** to raise awareness about sustainable land use/development practices. In addition, space is specifically dedicated to act as a meeting place in relation to implementing these practices upstream and in other parts of Sam Neua to reduce deforestation and flood and drought hazards. A separate second story will provide space for a café/bar to provide economic incentives (O4, O7, O9, O10). **S5.3 Multi-purpose Recreational Field:** Dedicated space for recreational activities such as football, aerobics and walking to increase human wellbeing and promote exercise as well as

	acting as a community gathering point. In addition, the field can be used for temporary markets and mobile food trucks too provide economic benefits during the dry season (O6, O10). **S5.4 Stilted restaurant** Southwest of the main park a restaurant elevated on stilts will provide an opportunity to experience the park, maintain economic opportunities, while acting as a dedicated flood zone during the wet season. It could host several booths, main and side buildings, dry season garden and visitor elements as well as the already existing fishpond, while being connected to the main park through a bridge. Parking opportunities may be provided in already existing space by the government buildings east of the river. **S6.1 Implement rooftop rainwater harvesting:** The existing rooftop drainage systems on buildings adjacent to the park area will be adapted to store the water that runs off the roofs into tanks for each building. This water can be used for washing and watering plants. With rooftop cleaning and proper storage, it could also be used for cooking and drinking (O1, O8, O9). **S6.2 Implement infiltration trenches:** This solution consists of the implementation of infiltration trenches around the park site covering a total area of 2.4km approximatively and an area of 2,900m^2. This solution will enhance the soil's natural ability to drain water and help to replenish groundwater and preserve baseflow in rivers (O1, O2, O3, O4, O5, O8). **S6.3 Implement retention pond:** This solution consists of the construction of a retention pond covering a total area of 1,420m^2. This solution will serve multiple purposes, where in addition to her major role in biodiversity preservation and flood risk reduction, the retention pond will represent a storage facility to mitigate the effects of low runoff during the dry season (O1, O2, O3, O4, O5, O8). **S9.1 Dedicated Flood zones:** To reduce further loss of natural floodplains and clearly protect and dedicate areas that can seasonally flood without causing damage are recommended in conjunction with the WSADP (O1, O2, O3, O4, O8). **S9.2 Compensation on privately owned land:** Choosing suitable mechanisms or incentives to minimize loss of any further retention areas (for example through regulation, pricing, or payment schemes) reflecting the benefit of preventing costly damage to downstream investments that would compare to the lost retention area of ca.114,000m^3 in the local valley (O7, O9). (For more information see Annex **Table of Interlinkages of Objectives, Challenges, and Solutions**)
7	DESCRIPTION OF ACTIVITIES AND TIMEFRAMES **Feasibility Study (1 year)** • Identify the specific areas for passive and active ecological restoration (S1.1) • Design of seed and/or seedling sowing plants (S1.1) • Analysis of channel and hydrological conditions (S2.1, S2.4) • Assess sites for erosion control measures (S2.2, S2.3) • Determination of Riprap dimensions (cages, rock shape and size) (S2.1) • Area survey and determination of bundle and terrace locations and dimensions (S2.2, S2.3) • Identify suitable locations and element types (S2.4) • Link the multi-purpose park in the extension of the DEWATS and Drainage System extension area (WSDAP) (S3.1) • Conduct a comprehensive survey and mapping of all known illegal dumping sites within the park boundaries (S4.1)

	• Coordinate and link the proposed site with the areas concerned with the extension of the solid waste services and with the public awareness campaigns according to the WSDAP (S4.2) • Identify and test feasible alternative ways of building in areas of high exposure to adapt to natural hazards with natural building materials that maintain function of flood retention (S5.1, S5.4) • Hold a cross-departmental meeting to identify responsibilities for the creation of educational information and awareness raising on the 6 key topics identified (S5.2) • Hold a community forum with local stakeholders and specifically discuss the envisioned economic benefits of alternative land use development with local land owners (S5.2, S5.3, S5.4) • Calculate rooftop rainwater harvesting potential and tank size (S6.1) • Conduct a site assessment to identify soil conditions and to determine the most suitable drought-tolerant and native plant species suitable for the park site and specifically for the infiltration trenches (S6.2) • Develop a planting plan that incorporates a diverse mix of drought-tolerant plants, including trees, shrubs, and groundcovers (S6.2, S6.3) • Identify stakeholders leading and involved in Upstream development (S7) • Inform and discuss with upstream stakeholders the basin challenges, creation of a River Basin Management Plan and pilot projects for agroforestry and / or ecotourism (S7, S8) • Identify land ownership titles around the park and the responsible department (S9.1, 9.2) • Meet and discuss potential compensation initiatives and how to bring this into practice in the park, throughout the urban extension areas and river basin (upscaling potential) (S9.2) **Implementation (2-3 years)** • Collection and preparation of material (seeds and sowing plants) (S1.1) • Planting of seeds and sowing plants (S1.1) • Protection and conservation of restoration sites (S1.1) • Erosion control site preparations (S2.1, S2.2, S2.3) • Implementation of Riprap structure along bank (S2.1) • Placement of living-wood bundles (S2.2) • Planting of hedgerows (S2.3) • Placement of deflecting elements in river channel (S2.4) • Develop site-specific remediation plans, which includes: Excavation and removal of contaminated soil; in-situ treatment of contaminated soil through bio-stimulation and revegetation and landscaping of the remediated areas (S4.1) • Implement the remediation measures in phases, prioritizing the most severely impacted sites (S4.1). • Dedicate space for recreational activities in a natural environment (S5.1). • Prepare a process to implement the adapted form of building in the park and local surroundings (S5.1, S5.4). • Design of public recreational and educational space (S5.2). • Design of information materials for panels and building (S5.2)

	• Create a public space for awareness raising and workshops related to alternative land use practices and development (S5.2). • Adapt current rooftop drainage pipes into rainwater harvesting systems and connect tank (S6.1) • Implementation of the infiltration trenches starting from soil excavation, installation of the pipes and geotextile to prevent soil migration, then install gravels to create a subsurface storage reservoir, and finally plant vegetation around the trenches (S6.2). • Construction of the retention pond starting from soil excavation, installation of the pipes to prevent water seepage (if necessary), then install the geotextile and gabions to stabilize the pond and finally plant vegetation around the pond (S6.3). • Implement mulching practices around plants to reduce evaporation and suppress weed growth (S6.2). • Implement permeable surfaces, such as porous pavement or gravel, for pathways and parking areas to reduce runoff and promote groundwater recharge (S6.3) • Ensure proper drainage to prevent waterlogging and promote healthy plant growth (S6.3) • Raise awareness for watershed related activities on local challenges, the concept of river basin management and alternative land use practices through solutions, such as agroforestry concepts, ecotourism or compensation schemes supported by appropriate visualizations (S7, S8). • Outline a process for a functional River Basin Management Plan including controlled alternative land use development practices with dedicated flood zones and suitable compensation incentives for the next 15 years (S7, S8, S9.1, S9.2). • Link the local dedicated flood zones to the land use development plan (S9.1). **Operation and Maintenance (continuous)** • Replanting of vegetation not surviving; watering and pruning of plants; maintenance of protective elements used in passive restoration (e.g. fences and wires) (S1, S2.2, S2.3). • Long-term replacement of Riprap cages and rocks (S2.1) • Check and maintain rainwater harvest systems regularly for wear and damage (S6.1) • Regular cleaning of rooftops and rainwater harvesting system (S6.1) • Aerate the soil regularly to improve water infiltration and root growth (S6.2) • Conduct regular inspections and maintenance for the effective operation of the retention pond and infiltration trenches: removal of litter, debris, nuisance plants, and sediments (S6.2 & S6.3). • Maintain the natural condition of the identified flood plain in and around the park using suitable compensation incentives for privately owned land (S9.2). **Monitoring and Evaluation (1-4 years)** Details in the ANNEX II, to identify if expected results are reached after the project implementation.
8	**TARGET GROUPS** • DPWT, DoNRE, DHUP, as well as corresponding Ministries on the watershed level • Landowners • Major private investors in the local area (road crossing) as well as the upstream watershed • Citizens in the surroundings of park site and Sam Neua village and the upstream watershed • Local and foreigner tourists

9	EXPECTED RESULTS AND TIMEFRAME
	Enhancing resilience to extreme events (Floods and Droughts) in Sam Neua • Reduced water runoff in the 10m buffer riparian vegetation **(S1.1)** • Increased preparedness for dry periods in terms of water availability **(S6.1, S6.2)** • Supply of alternative water resources (from retention pond and rooftop rainwater harvesting) for reuse in park services maintenance or personal use by locals (neighboring the park site) **(S6.1, S6.3)** • Ensuring the flood retention capability of 100% (ca. 2.5 ha) of the area **(S9.1)** **Enhancing biodiversity of riparian vegetation in Sam Neua** • 100% of the 1.4 Ha of Riparian Vegetation restored **(S1.1)** **Reducing the risk of erosion processes in Sam Neua** • Implementation of 100% of planned erosion control structures after **(S2.1, S2.2, S2.3, S2.4)** • Erosion rate in park area reduced by minimum of 80% after **(S2.1, S2.2, S2.3, S2.4)** • 80% of targeted bank and slope areas covered by vegetation **(S2.2, S2.3)** **Mitigating environmental and health risks (Water Quality and Solid Waste)** • 100% of the multi-purpose park extension covered by the DEWATS and Drainage System extension area (WSDAP) **(S3.1)** • Cleaning and rehabilitation of 100% of sites polluted with solid waste (construction waste or other type) dumped illegally in the proposed park site **(S4.1)** **Promote hazard-resilient projects and construction methods** • Construction of 100% of adapted structures in and around the park **(S5.1, S5.4)** **Enhancing the health and well-being of Sam Neua locals** • Create a respite for the local population to engage in physical activities (walking, running, playing sports), and to enhance social cohesion (socialize, build community identity and belonging) **(S5.1)** **Providing capacity building to promote Water-Sensitive Urban Design** • Display of materials related to all 6 key topics identified with at least 1 panel and visualization each **(S5.2)** • Raise awareness of 100% of local and 50% upstream stakeholders for alternative land use and development practices through respective events (**S5.2)** **Reducing pressure on existing and future water infrastructure** • Rooftop rainwater harvesting systems to be implemented on 80% of buildings local to the park **(S6.1)** • Reduction of piped water supply demand by 50% on buildings with rainwater harvesting systems **(S6.1)** • Storing a volume of water ranging between 1,704m^3 and 2,840m^3, to mitigate the effects of the dry season, enhance biodiversity, and combat erosion **(S6.3)** • Maintain 100% (ca. 75 000 m^3) of the current retention potential in the park area given a 3m flood wave (**S9.1)** **Promoting cohesive and inclusive management practices** • 100% agreement on the process, steps and involved stakeholders to establish a River Basin Management Plan and related elements for the next 15 years (**S7, S8)** • Identification of 3 different options for locally applicable compensation mechanisms **(S9.2)** **Provide examples for economic benefits aligned with sustainable land development** • Develop 3 different options for economic use of the park area without compromising flood holding capacity **(S5.2,S5.3,S5.4).**

<table>
<tr><td>10</td><td> ESTIMATED BUDGET Provide an estimated budget for the project (BORDA)</td></tr>
<tr><td>11</td><td> MONITORING AND EVALUATION The Monitoring and Evaluation Framework (MEF) for the multi-purpose Park in Sam Neua Village will be structured around three steps: Definition of evaluation questions, selection of indicators, and data collection methods. Refer to ANNEX II to access the complete MEF.</td></tr>
<tr><td>12</td><td> RISK AND CHALLENGES Deforestation upstream or landfilling would increase flood hazard and erosion risk and limit the effect of the park plan.
Unclear mandates, responsibilities, and administrative processes to implement mechanisms could make the process of river basin plan development or compensation schemes.
Time-intensive process to implement long-term solutions like agroforestry or ecotourism.
Limited effect of the park on health and human well-being due to restricted access or limited acknowledgement of citizens because of the absence of community involvement during the design phase.
Lack of on-going monitoring of environmental, social, and technological indicators over a longer period to maximize the benefits of initiatives and minimize the risks of worsening existing vulnerabilities.</td></tr>
<tr><td>13</td><td> APPENDICES Include any supporting documents, maps, diagrams.
ANNEX I Tables, Images and Maps
ANNEX II Monitoring and Evaluation
ANNEX III Physical characteristics and watershed</td></tr>
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ANNEX I Tables, Images and Maps

A/ Maps and Images for Challenges in the Project Site
B/ Maps and Images for Challenges in the Watershed Level
C/ Maps and Images for Solutions in the Project Site
D/ Table of Interlinkages of objectives, challenges, and solutions
E/ Rooftop Rainwater Harvesting
F/ Links to assessment maps and materials

A/ Maps and Images for Challenges in the Project Site

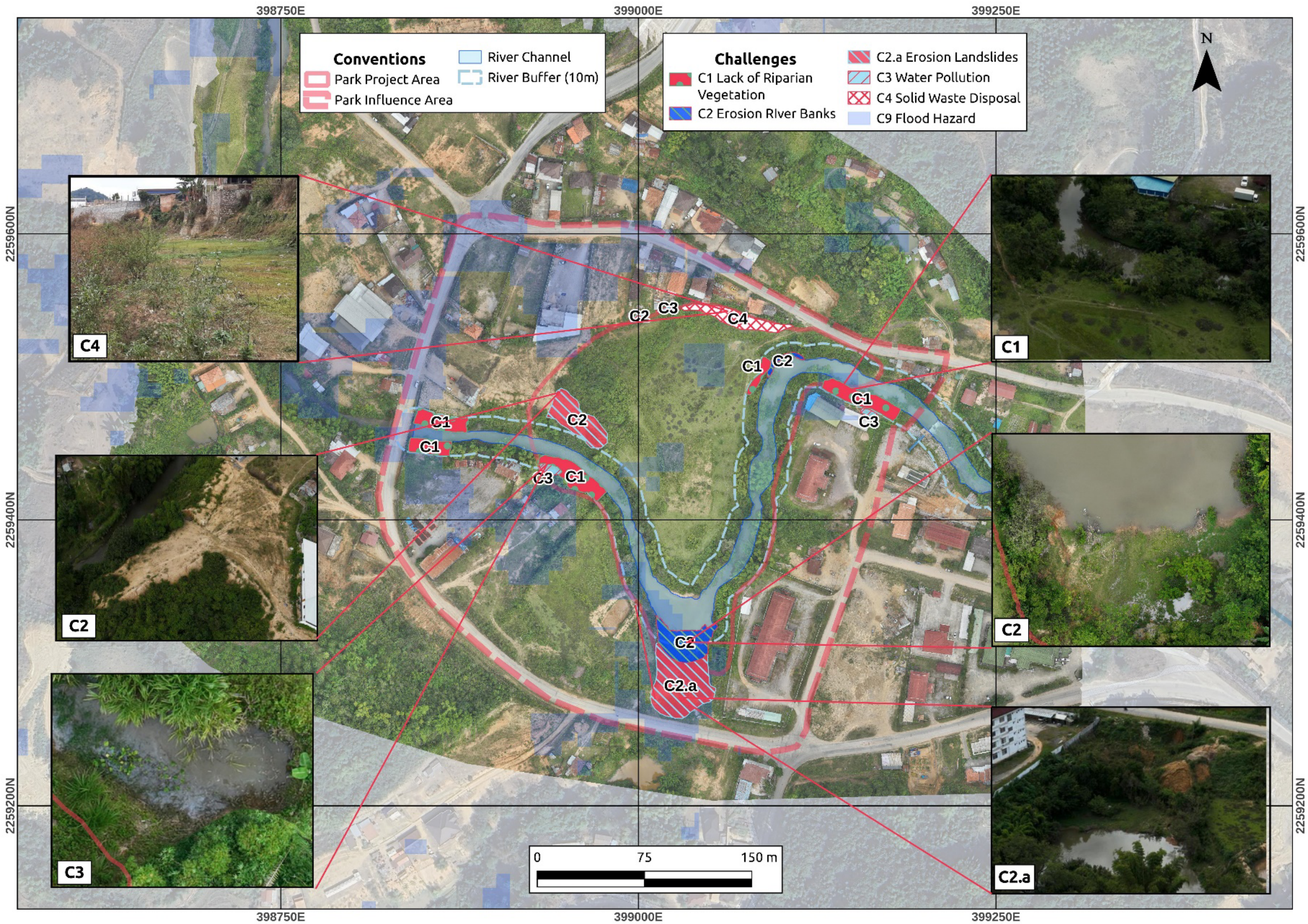


Figure 1. Identified Challenges in the study area

Figure 2. Historical land use and land cover change of the area from 2013-2023

Figure 2. Historical land use and land cover change of the area from 2013-2024

B/ Maps and Images for Challenges in the Watershed Level

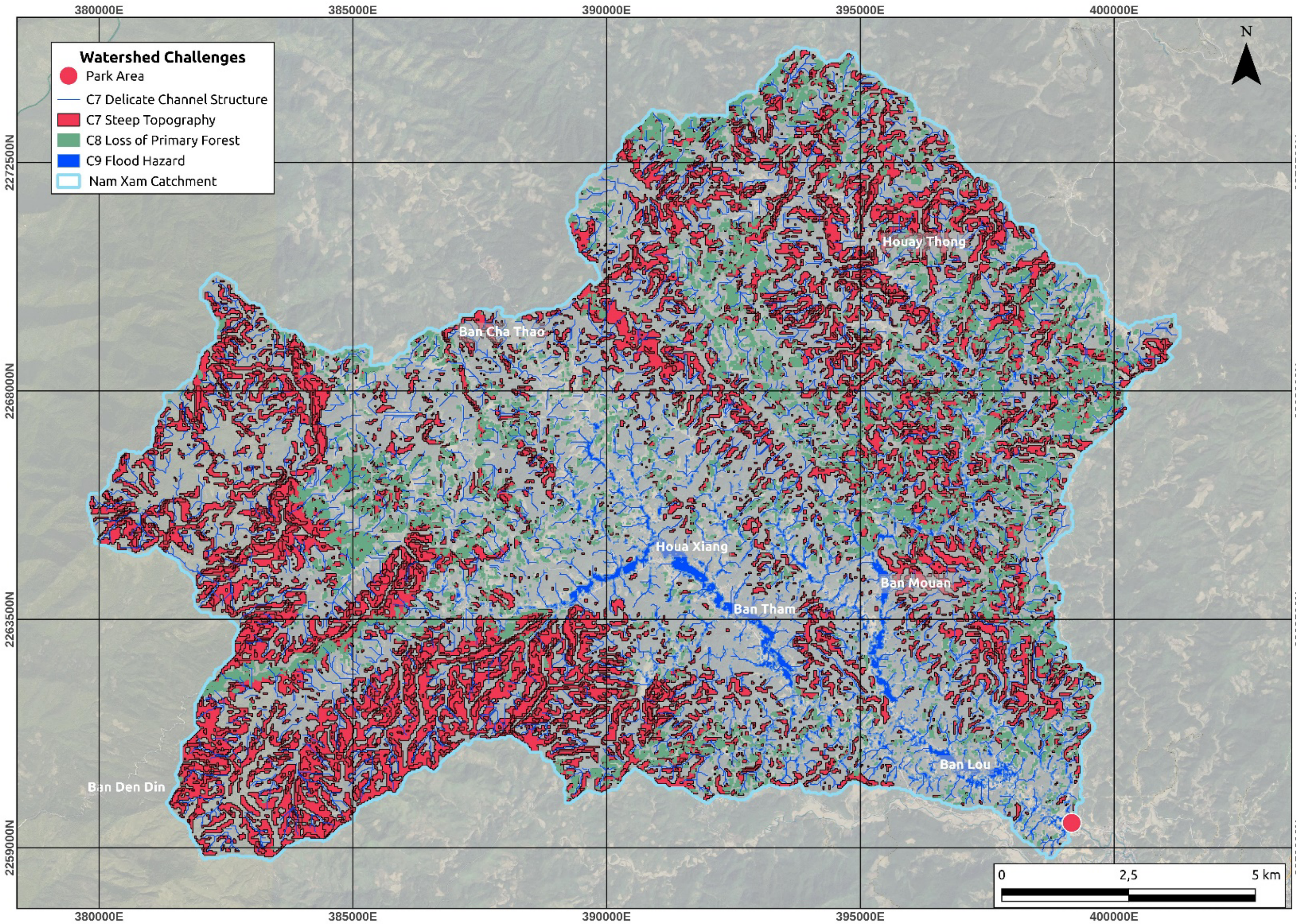


Figure 3. Identified Challenges in the Watershed

C/ Maps and Images for Solutions in the Project Site

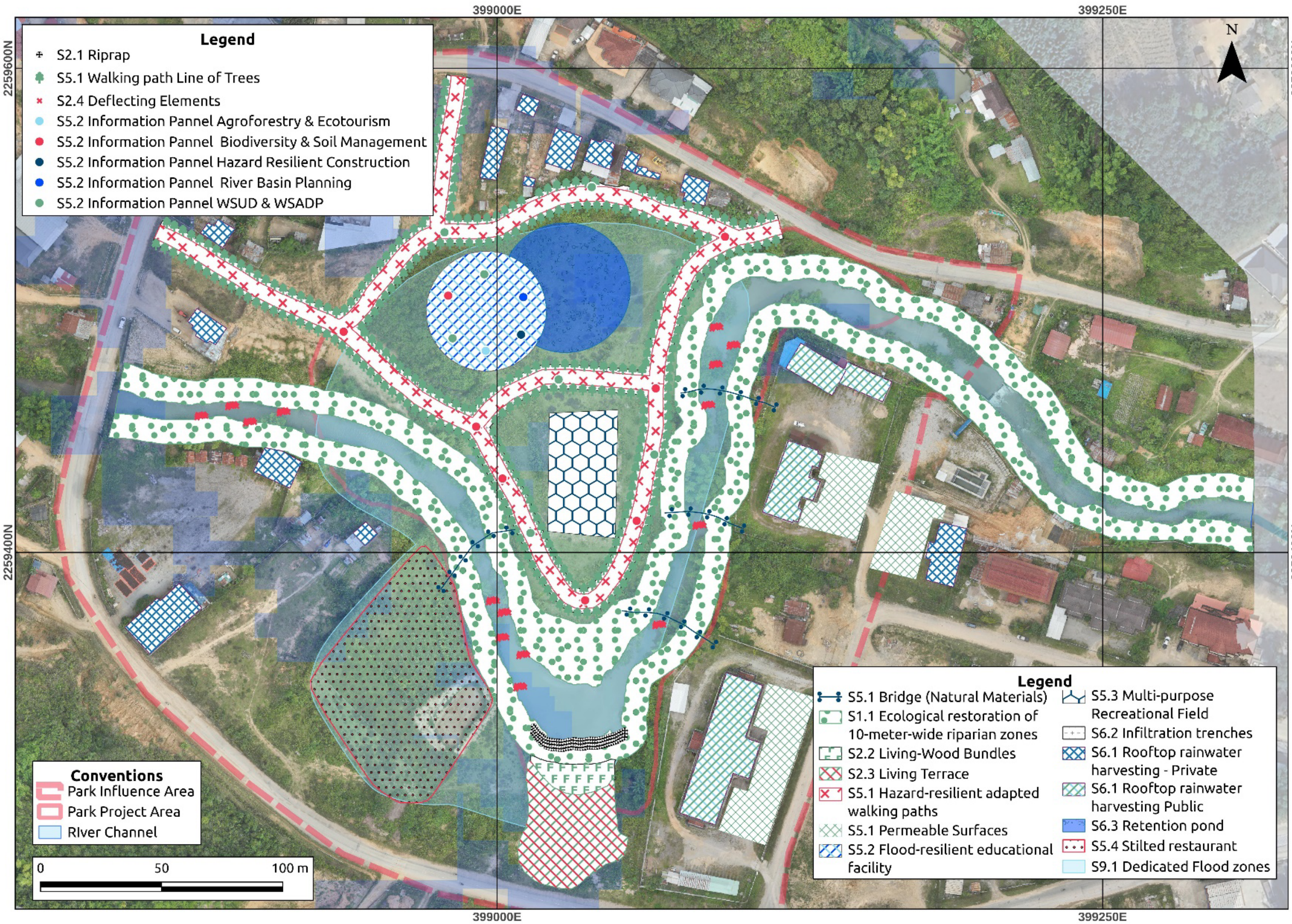
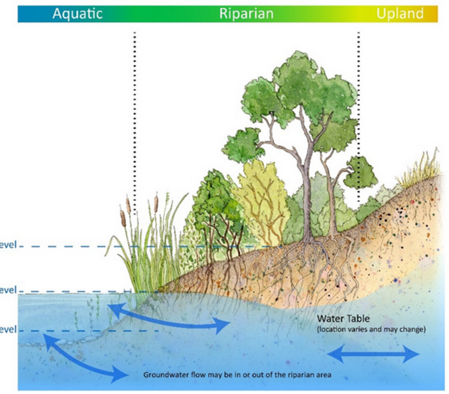
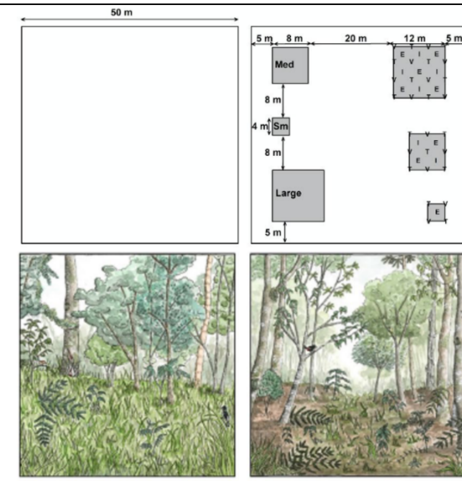


Figure 4. Proposed Solutions for the study area

<table>
<tr><th>Solution</th><th>Example</th><th>Scheme</th></tr>
<tr>
<td>S1.1 Ecological restoration of 10-meter-wide riparian zones

Preserve and isolate mature riparian vegetation aiming to facilitate natural regeneration. In areas without riparian vegetation, the strategy is to plant species (applied nucleation) that reflect the composition and structure of the native riparian vegetation.</td>
<td>

https://experience.arcgis.com/experience/6f36edb6d53241f9a85f653f0db1c3a8/page/Riparian-Areas/#data_s=id%3AdataSource_20-Riparian_5219%3A15</td>
<td>

Natural regeneration Applied nucleation

(Wilson et al. 2021) Wilson, S. J., Alexandre, N. S., & Reid, J. L. (2021). *Applied Nucleation Restoration Guide for Tropical Forest*.</td>
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<td>S2.1 Riprap

Riprap consists of tactically placed rocks or gabions along the riverbank to form an effective protective barrier.</td>
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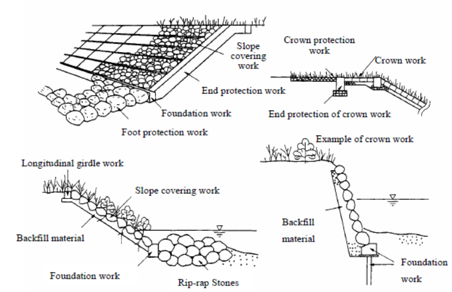
https://openjicareport.jica.go.jp/pdf/11774973_02.pdf</td>
<td>g) Foot protection work


Figure 2.2.1 Structure of Revetments
https://www.scribd.com/document/429434894/124sfsr2124tater121gd24</td>
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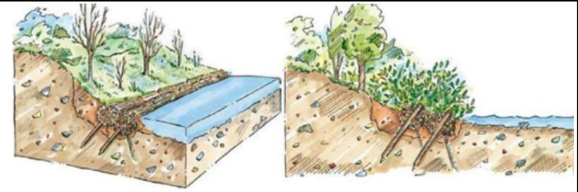
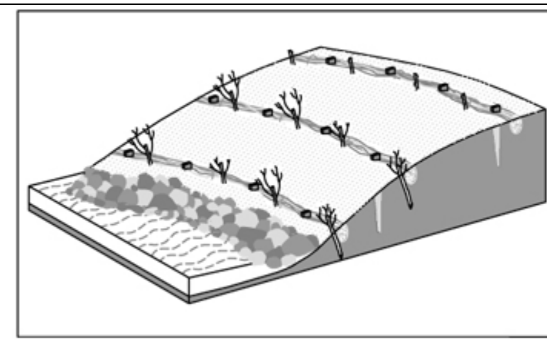
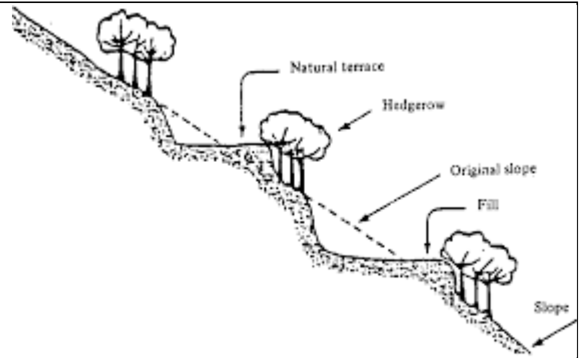
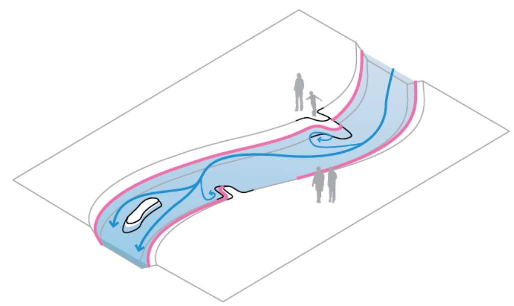
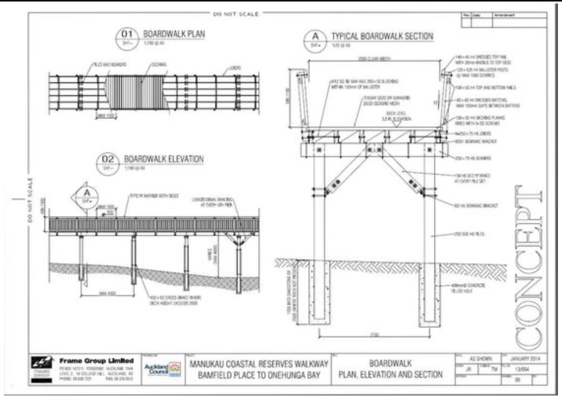
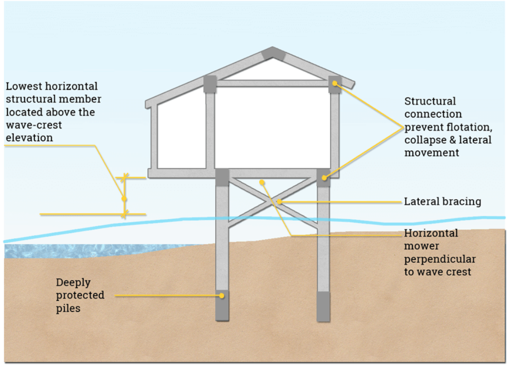
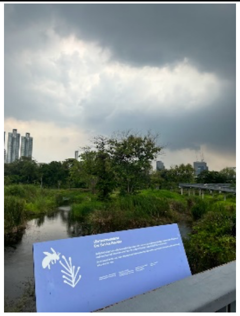
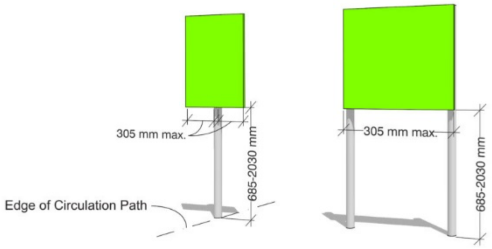
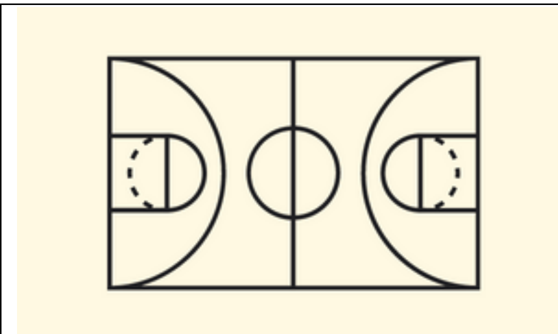
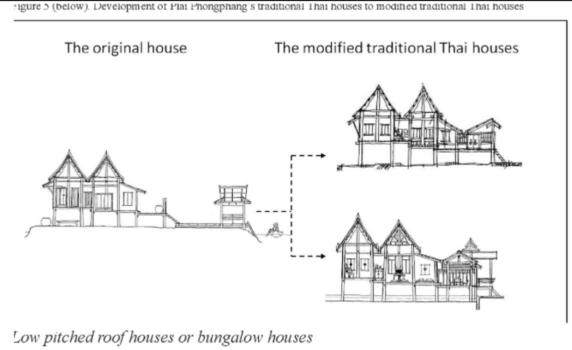
S2.2 Living-Wood Bundles Also known as living fascines. They are bundles of living sticks placed in rows along the banks and slopes. They provide direct protection and grow over time and the roots will help to support the bank and vegetation will help to protect the surface whilst increasing biodiversity.	  https://openjicareport.jica.go.jp/pdf/11774973_02.pdf	 Living fascines - before and after growth of vegetation cover. Source: Unalab, 2019
S2.3 Living Terrace Living terraces are formed by planting vegetation in rows along the contours of the slope. The vegetation collects sediments from runoff over time to form natural terraces.	 https://qcat.wocat.net/af/wocat/technologies/view/permalink/1000/	 http://www.extranet.vdot.state.va.us/locdes/hydraulic_design/nchrp_rpt544/content/html/Live_Fascines/typical_drawings/lfbg.jpg

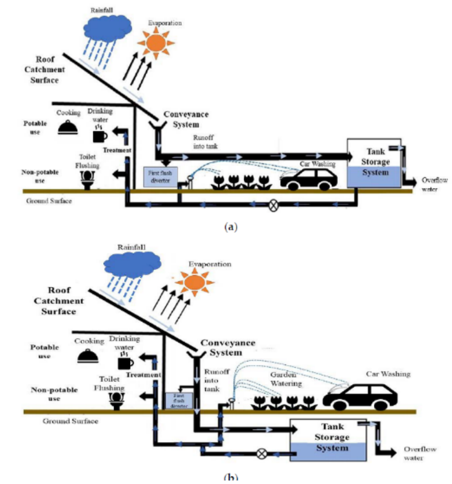
		 https://www.incalaquila.it/how-can-afforestation-prevent-soil-erosion-how-could-it-tt-mGGMmRUM
S2.4 Deflecting Elements Deflecting elements are natural-based objects placed in the river to alter the stream and reduce the overall velocity of the river which reduces the erosive force.	 (Prominski et al. 2017)	 (Prominski et al. 2017)
S5.1 Hazard-resilient adapted walking paths	 Source: Adobe Stock Sutongpe Bridge	

	 Source: Shutterstock – Bamboo bridge at Green School, Bali, taken from The Jakarta Post	 Source: Pinterest -Manuka coastal Reserve walkway- New zealand
S5.2 Flood-resilient educational facility	 Example of a building on stilts in Bali. Source: https://amusementlogic.com/general-news/prefabricated-modular-houses-on-stilts-in-bali/	 Source: https://andhitapradipta.github.io/ternate-tsunami/house-on-stilts.html

	 https://www.re-thinkingthefuture.com/article/how-is-bamboo-redefining-architecture-in-recent-times/	
S5.2 Information panel	  Information panel in Chicago and Bangkok. Source: (Hoxha, Xh, 2023)	 Information panels can be placed over a big stone or post mounted (e.g. Material can be wood or metal) to suit any location. Source: https://dosobo-access.wbdg.org/aba-chapters/figure/307-3-post-mounted-objects/

S5.3 Multi-purpose Recreational Field	 Multi-purpose Court in Singapore Source: https://wctc.org.sg/constituency-facilities-locator/	 Source: https://wctc.org.sg/constituency-facilities-locator/
S5.4 Stilted restaurant	 Source: Eric Dinardi , taken from stir world – Façade of the Jujang building West java / Indonesia	 Source: Nimsamer & Wallimann (2013) Development of Plai Phongphang's traditional Thai houses to modified traditional Thai houses

<table>
<tr>
<td>S6.1 Implement rooftop rainwater harvesting

The existing guttering/drainage systems can be adapted to form rainwater harvesting systems by adding storage tanks. This water can be used for irrigation, sanitation and cleaning.</td>
<td>
(Jacq et al,. 2018)</td>
<td>

(Zabidi et al, 2020)</td>
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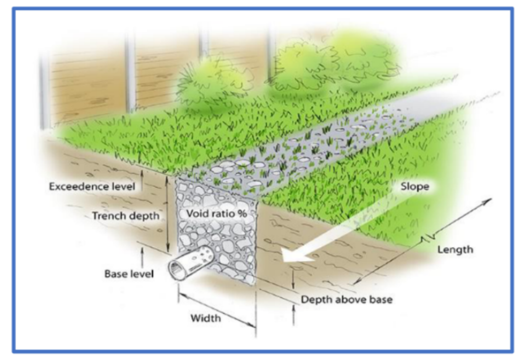
<td>S6.2 Implement infiltration trenches
An infiltration trench is a shallow excavated trench filled with stone or other highly permeable material designed to temporarily store stormwater runoff and allow it to infiltrate into the underlying soil layers.</td>
<td></td>
<td>

Figure 2- 7: Infiltration trench (XP Drainage, 2017)</td>
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S6.3 Implement retention pond

Retention ponds are water bodies which hold water allowing particles to settle and biological treatment. They are also one of the most effective storm water management installations for removing storm water pollutants and allowing water infiltration into soil and aquifers.

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[Chulalongkorn Centenary Park | Urban Nature Atlas (una.city)]()

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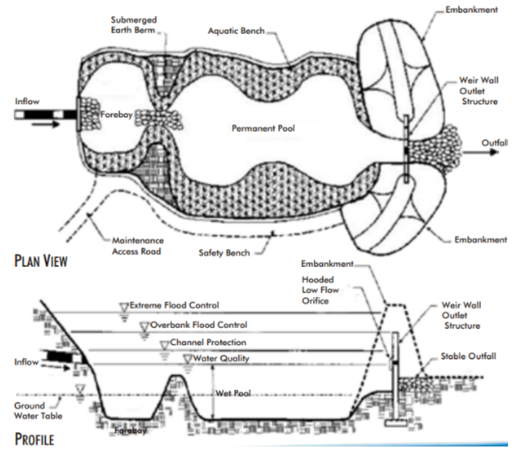

https://sswm.info/sites/default/files/reference_attachments/GDSDS%202005%20Retention%20Ponds.pdf

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S7 River Basin Planning

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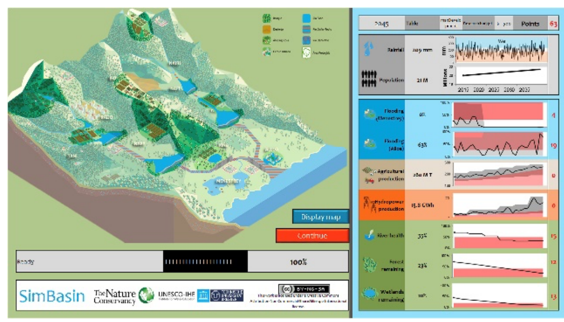

Source: Cranven et al., 2017

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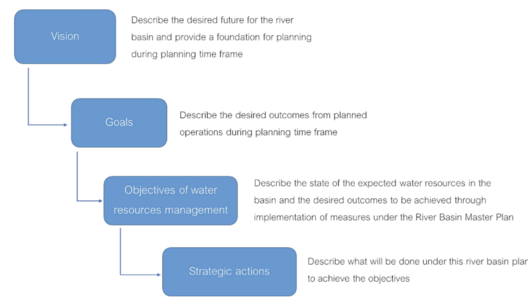

Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2022 - Guideline for Climate-Sensitive River Basin Master Plan (RBMP) Development Process

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<td>S8 Alternative Forest management practices</td>
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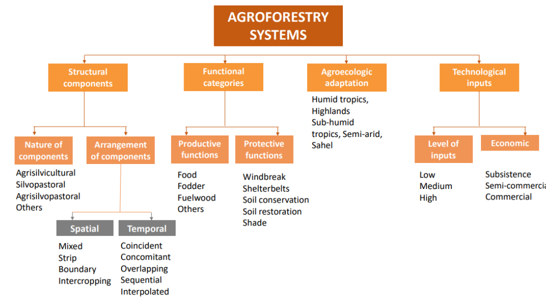
Source: Zimmer et al., 2022</td>
<td>

Source: Xu et al 2013 in Mulia et al, 2021Diversity of agroforestry practices in Viet Nam https://cgspace.cgiar.org/items/ef4ffe32-79a2-4725-8110-98fc2d53a7a0</td>
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<tr>
<td>S9.1 Dedicated Flood zones</td>
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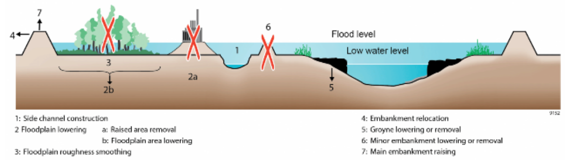
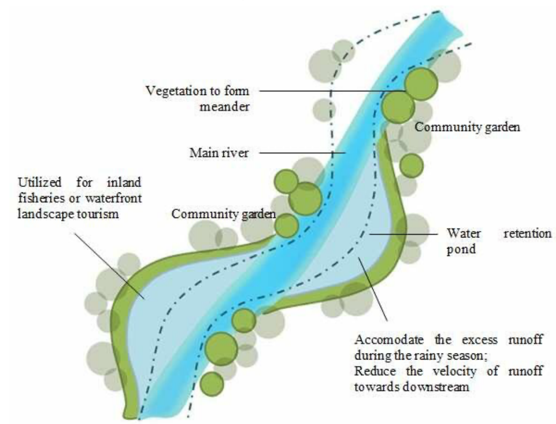
<td>Floodplain of the Ijssel river before (left) and after (right) the Room for the River project. Credits: Rijkswaterstaat, taken from Water Cliamte and Future Deltas, Utrecht University Room for the River</td>
<td>


Source: A selection of measures taken in the Room for the River project. Source: Straatsma et al. (2019), taken from Water Cliamte and Future Deltas, Utrecht University Room for the River


Source: Noviandi et al., 2017, Riparian landscape management in the midstream of Ciliwung River as supporting Water Sensitive Cities program with priority of productive landscape
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D/ Table of Interlinkages of Objectives, Challenges, and Solutions

No	Challenge	Solution (Description of the project)	Objective
1	**C1** Lack of riparian zones and lack of vegetation	**S1.1** Ecological restoration of 10-meter-wide riparian zones	O1, O2, O3
2	**C2** Erosion (*Landslide, Sedimentation*)	**S2.1** Riprap **S2.2** Living wood Bundles **S2.3** Living Terrace **S2.4** Deflecting Elements	O2, O3, O9
3	**C3** Water pollution	**S3.1** Wastewater and Stormwater Management Plan **S4.1** Restore and Rehabilitate Waste Dumping Sites **S4.2** Waste Management Plan and on-site waste disposal options	O1, O2, O4, O6, O8
4	**C4** Illegal solid waste disposals	**S4.1** Site cleaning and rehabilitation **S4.2** Inclusion of site park in plan of WSADP	O4, O6
5	**C5** Land use changes in natural flood plains	**S5.1** Hazard-resilient adapted walking paths **and surfaces** **S5.2** Flood-resilient educational facility and information panels **S5.3** Multi-purpose Recreational Field **S5.4** Stilted restaurant	O1, O4, O5, O6, O7, O8, O9, O10
6	**C6** Drought hazard	**S6.1** Implement rooftop rainwater harvesting **S6.2** Implement infiltration trenches **S6.3** Implement retention pond	O1, O2, O3, O4, O5, O8, O9
7	**C7** Steep topography and delicate channel structure	**S7** River Basin Planning linked with S5.2	O1, O7, O9
8	**C8** Loss of primary forest	**S8** Alternative Forest management practices linked with S5.2	O1, O7, O9, O10

9	**C9** Flood hazard	**S9.1** Dedicated Flood zones **S9.2** Compensation to privately owned land	O1, O2, O3, O4, O8, O10 O7, O9

E/ Rooftop Rainwater Harvesting

Buildings adjacent to the park were considered for rooftop rainwater harvesting. The map and table above provide an overview of their locations and characteristics. To calculate rainwater water harvesting potential, the area of the rooftop surface, the precipitation and the runoff coefficient are needed. The runoff coefficient is used to reflect how much of the precipitation that lands on a surface becomes runoff.

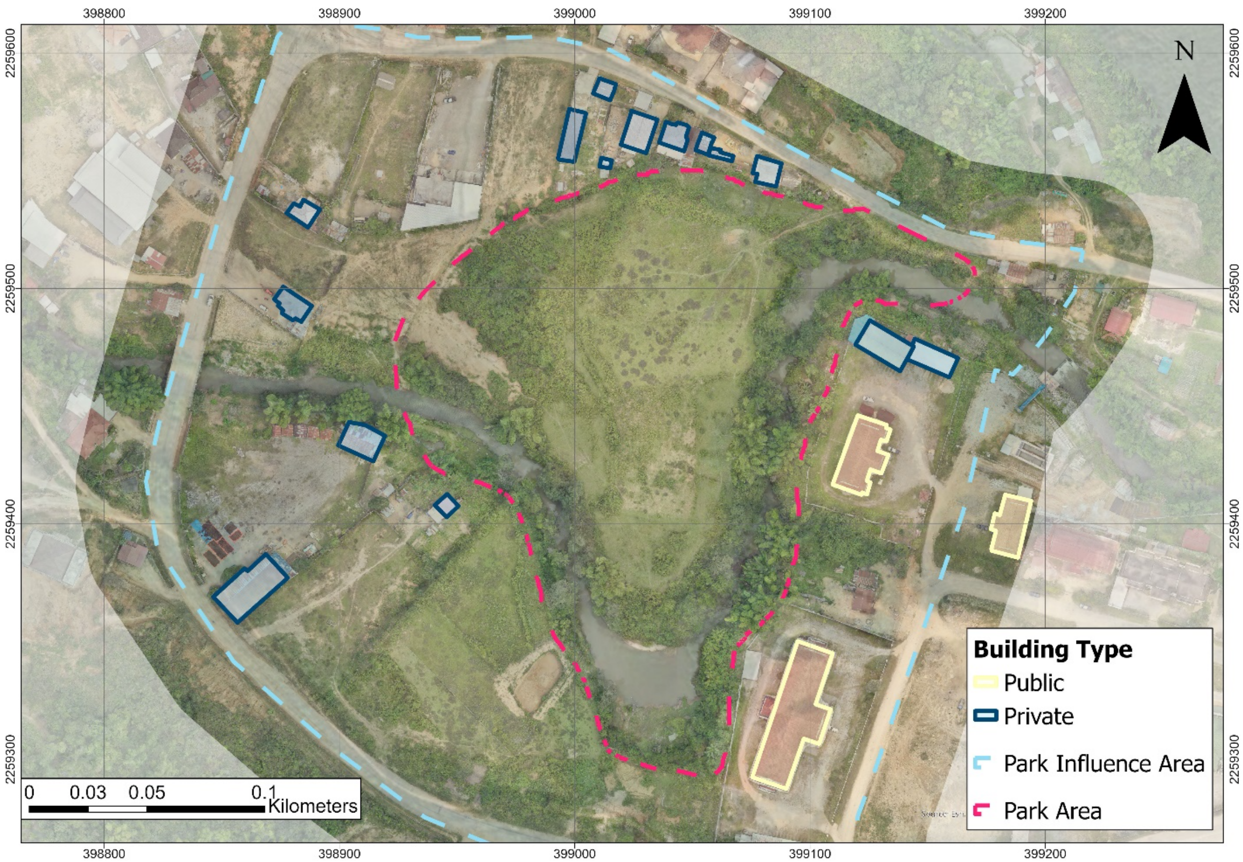


Figure 5. Map of buildings selected for rainwater harvesting by roof type

Table 2. Information regarding Building ownership type, roof area, roof material, and runoff coefficient

Building Type	Roof Type	Roof Area (m3)
Public	CPAC Tile	1830.0
Private	Corregated Zinc	759.7
	CPAC Tile	754.3
	PVC	492.2
	Total	2006.2

Table 3. Total rainwater harvesting potential of all selected buildings in the study area, categorized by building ownership

Building Type	Area (m2)	Runoff Coefficient	Assumed Losses (%)	Annual Total (m3)	Annual (m3/m2)
Private	2006.20	0.92	20	1956.19	0.98
Public	1830.00	0.9	20	1745.59	0.95
Cumulative	3836.20	-	-	3701.78	0.96

The above table is the result of multiplying the annual precipitation with the catchment area and runoff coefficients for each roof surface type. The runoff potentials are determined by the proportion of each rooftop material present in each building ownership type.

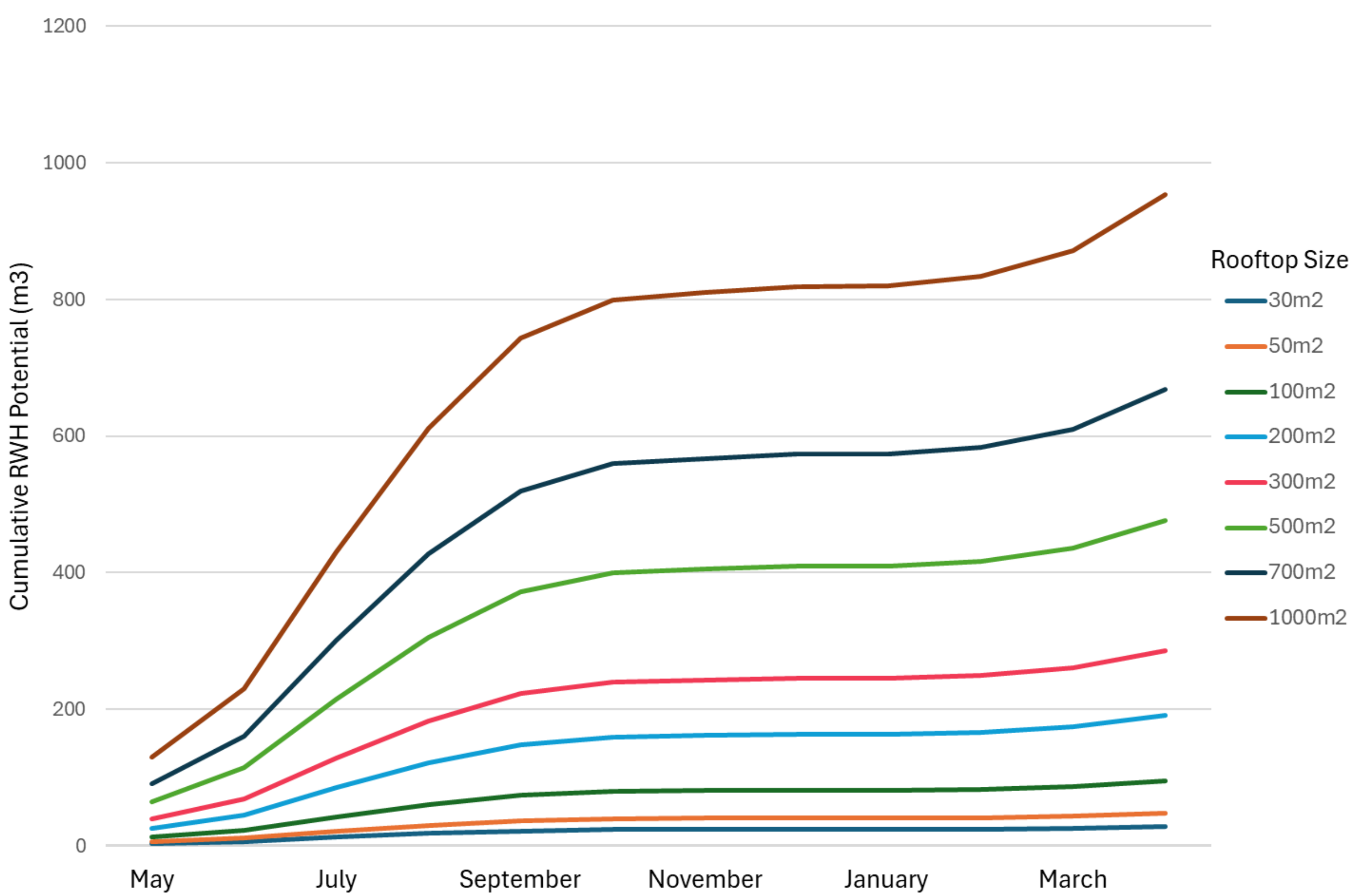


Figure 6. Annual Rooftop Rainwater Harvesting (RRWH) potential by roof size (assuming concrete tiles or corrugated zinc as roof material).

Figure 6 shows the different rainwater harvesting potentials of different roof area surfaces based on the monthly rainfall in the Sam Neua park site. Many rooftops in the study area are between 100-500m^2, which shows that the amount of water that could be collected is significant.

F/ Links to assessment maps and materials (Print versions in Annex III)

- **Local drone 360 ° images:** https://momento360.com/e/uc/13634b419cab44d4b52573ee9da20c28?utm_campaign=embed&utm_source=other&size=large&display-plan=true&upload-key=00007df8cf0d450598ad560046ec4aa8
- **Drone images :** https://felt.com/map/Multi-Functional-Riverbend-Green-Space-Recreation-Park-Drone-images-6HfNJd2uT9CuVejdJN2pgDC?loc=20.431563,104.03154,17.13z&share=1
- **3D Point cloud model**: Multi-functional Riverbend Green Space / Recreation Park in Sam Neua Village _test-1 - WebODM Lightning
- **Watershed challenge map:** https://felt.com/map/Watershed-challenges-p9AMa9ASObQdOl6kD6Rc6hSC?loc=20.49225,103.96212,12.56z&share=1
- **Topography and catchment information:** https://felt.com/map/Contextualization-Hydrology-RjnE7rimRdS7n4IAp9BXNjA?loc=20.4611,103.95051,11.84z&share=1
- **Primary forest loss trends:** https://gfw.global/3Q5D3eM
- **Landcover:** https://felt.com/map/Contextualization-Land-cover-use-change-igSqOWEAT8aWZZ6Unc19CMB?loc=20.47635,103.9145,12.03z&share=1
- **Processed Flood hazard assessment:** https://felt.com/map/Contextualization-Flood-hazard-assessment-Vq9COx8lASbiik0Zmj4Kt6C?loc=20.47958,103.95465,13.19z&share=1

Annex II. Monitoring and evaluation

It is necessary to establish a monitoring and evaluation (M&E) framework to ensure that the project's objectives and design are well articulated. The framework will allow monitoring and evaluation of the project's performance and success, while generating useful information for future improvement and accountability. The M&E framework for the Multi-Functional Riverbend Green Space/Recreation Park in Sam Neua Village will be structured around two key steps: Definition of evaluation questions, selection of indicators, and data collection methods. This could include application of GIS, Drone and Water quality sampling on a bi-annual basis to measure the progress and effectiveness.

Defining the Evaluation Questions

The establishment of evaluation questions for the Multi-functional Water-Sensitive Park in Sam Neua Village is a significant matter. It looks for the concrete effect of the programme in solving certain problems and achieving the set objectives. The evaluation focuses on providing evidence of the multiple causal effects of the park and the factors responsible for the various environmental benefits, such as flood control in the village and conservation through improved water management, increased green space and additional recreational facilities.

Ultimately, the evaluation aims to assess whether the effectiveness of the park was higher than the situation without the intervention or the situation with the alternative non-NbS interventions. This precision is achieved through the questioning process, which leads to an in-depth understanding of the theory of change and the identification of appropriate indicators. It is a matter of identifying which external factors may influence the results in certain locations and projects. This identification of factors outside the direct control of the Park allows us to clearly identify the actions related to the Park that have influenced the outcome

.

General Questions	Evaluation Questions	Topic	Indicators
How does the Multi-functional Riverbend Green Space / Recreation Park contribute to improving water quality in the Sam Neua Village?	What is the total suspended solids (TSS) content in the water within the park?	Water Management	Total Suspended Solids (TSS) content
	How does the park contribute to flood peak reduction and delay?		Flood peak reduction and delay
	What is the runoff rate for different rainfall events within the park?		Runoff rate for different rainfall events
	What is the pH of the NBS effluents in the park?		pH of NBS effluents
	What is the electrical conductivity of the NBS effluents in the park?		Electrical conductivity of NBS effluents
How does the Multi-functional Riverbend Green Space / Recreation Park enhance green space management in Sam Neua Village?	How accessible is the green space within the park to the community?	Green Space Management	Green space accessibility
	What ecosystem services are provided by the park?		Ecosystem service provision
	How many visitors are there in the new recreational areas within the park?		Number of visitors in new recreational areas
	What are the reasons for visits to the NBS area within the park?		Number of and reasons for visits to an NBS area
	How frequently are the green and blue spaces within the park used?		Frequency of use of green and blue spaces
	What activities are allowed in the recreational areas of the park?		Activities allowed in recreational areas.
How does the Multi-functional Riverbend Green Space / Recreation	What is the structural connectivity of the green space within the park?	Biodiversity Enhancement	Structural connectivity of green space

General Questions	Evaluation Questions	Topic	Indicators
Park contribute to enhancing biodiversity in Sam Neua Village?	How does the park contribute to the functional connectivity of urban green and blue spaces?		Functional connectivity of urban green and blue spaces
	How many native species are present within the park?		Number of native species
	How many non-native species have been introduced within the park?		Number of non-natives species introduced
	What is the species diversity within the defined area of the park per the Shannon Diversity Index?		Species diversity within defined area per Shannon Diversity Index
To what extent does the Multi-functional Riverbend Green Space / Recreation Park contribute to place regeneration in Sam Neua Village?	What is the quantity of blue-green space as a ratio to built form within the park?	Place Regeneration	Quantity of blue-green space as ratio to built form
	How is the perceived quality of urban green, blue, and blue-green spaces within the park?		Perceived quality of urban green, blue and blue-green spaces
	What is the level of place attachment (Sense of Place) and place identity within the park?		Place attachment (Sense of Place): Place identity
	How is the recreational value of public green space perceived within the park?		Recreational value of public green space

General Questions	Evaluation Questions	Topic	Indicators
How does the Multi-functional Riverbend Green Space / Recreation Park contribute to knowledge and social capacity building for sustainable urban transformation in Sam Neua Village?	How involved are the citizens in environmental education activities within the park?	Knowledge and Social Capacity Building for Sustainable Urban Transformation	Citizen involvement in environmental education activities
	What is the level of social learning regarding ecosystems and their functions/services within the park?		Social learning regarding ecosystems and their functions/services
	What is the level of pro-environmental identity among the park visitors?		Pro-environmental identity
	How does the park influence pro-environmental behavior among the visitors?		Pro-environmental behaviour
How does the Multi-functional Riverbend Green Space / Recreation Park contribute to the health and well-being of the community in Sam Neua Village?	What is the level of outdoor physical activity within the park?	Health and Well-Being	Level of outdoor physical activity
	What is the level of chronic stress (perceived stress) among the park visitors?		Level of chronic stress (Perceived stress)
	How does the park contribute to general well-being and happiness among the visitors?		General wellbeing and happiness
	How does the park influence self-reported mental health and well-being among the visitors?		Self-reported mental health and wellbeing

General Questions	Evaluation Questions	Topic	Indicators
	How does the park contribute to the overall quality of life of the community?		Quality of Life
How does the Multi-functional Riverbend Green Space / Recreation Park create new economic opportunities and green jobs in Sam Neua Village?	How many new jobs have been created as a result of the park development?	New Economic opportunities and Green Jobs	Number of new jobs created
	What is the level of retail and commercial activity in proximity to the green spaces within the park?		Retail and commercial activity in proximity to green spaces
	How many new businesses have been created, and what is the gross value added to the local economy as a result of the park?		Number of new businesses created, and gross value added to local economy
	What is the recreational monetary value generated by the park?		Recreational monetary value
	How does the park contribute to overall economic, social, and health well-being in the community?		Overall economic, social and health wellbeing

Selecting Indicators and Data Gathering

The main purpose of using indicators and collecting data is to help monitor how the park is working and whether there is alignment with the theory of change mentioned above. To ensure that the indicators are effective, they would be selected based on the SMART criteria - Specific, Measurable, Attributable, Achievable and Time-bound. These indicators consist of both performance indicators related to the thematic areas of the societal challenge and process indicators related to the implementation characteristics of the park. The next step is to ensure the coherence of the indicators, taking into account the synergies and trade-offs identified in the Theory of Change. Collaborative prioritization is necessary and should separate the indicators that have an impact on the essential outcomes of the park (core indicators) from those that are desirable but less critical (ancillary indicators). It's recommended to start with core performance indicators and then move on to others based on available resources and policy priorities.

Annex XX contains the pool of indicators, and this compilation may be useful to practitioners in selecting indicators to measure climate resilience, water management, green space management, biodiversity enhancement, air quality, place regeneration, knowledge and social capacity building, sustainable urban transformation, participatory planning and governance, social equity and cohesion, health and well-being, and the creation of new economic opportunities.

Monitoring through the application of Decision support tools for Water-sensitive-Urban Design:

GIS monitoring tools (See Decision support tool 1):

Apply regular reviews of upstream land use changes through the use of Global forest watch (Area in Xam Neua District, Houaphanh, Laos Interactive Forest Map & Tree Cover Change Data | GFW (globalforestwatch.org) and CTree Land use alters (CTrees). Furthermore, regular monitoring of upstream flood dynamics is recommended in applying tools available in the Copernicus Ecosystem (Copernicus Browser). Site visits to the identified hotspots are needed in order to validate the insights and documented with photographs and potentially high resolution imagery.

Drone monitoring tools (See Decision support tool 2):

Bi-annual of potentially more regular collection (recommended quarterly or even monthly in the first year) of photos of the side from all angles, 360 degree images and potentially orthomosaicks will enable regular evaluation of the need to adjust structural or organization aspects that guide the development and effectiveness of the park.

Water quality sampling monitoring(See Decision support tool 3):

Bi-annual collection of chemical (COD, heavy metals) and biological water parameters (BOD) potentially more regular collection of physical water quality parameters like PH, colour, conductivity or smell(recommended quarterly or even monthly in the first year) are able to create a baseline and monitor any trends of impact of the parc and related measures. This should include regular testing of harvested rainwater and river water. In addition it is recommended to establish a simple water level meter on the edge of the park to the river, where water level can be recorded on a daily based by a local assigned people. This could involve citizen science and be linked with the education aspects of the park.

Information management and visualization (See Decision support tool 4):

The collected information should be stored according to the FAIR Principles (Findable, accessible, Interoperable and reusable), appropriately interpretated and be shared with all governmental institutions and the public through practicable visualizations.

Annex III Physical characteristics and catchment

Local drone 360 ° images:

https://momento360.com/e/uc/13634b419cab44d4b52573ee9da20c28?utm_campaign=embed&utm_source=other&size=large&display-plan=true&upload-key=00007df8cf0d450598ad560046ec4aa8

3D Point cloud model= Multi-functional Riverbend Green Space / Recreation Park in Sam Neua Village _test-1 - WebODM Lightning

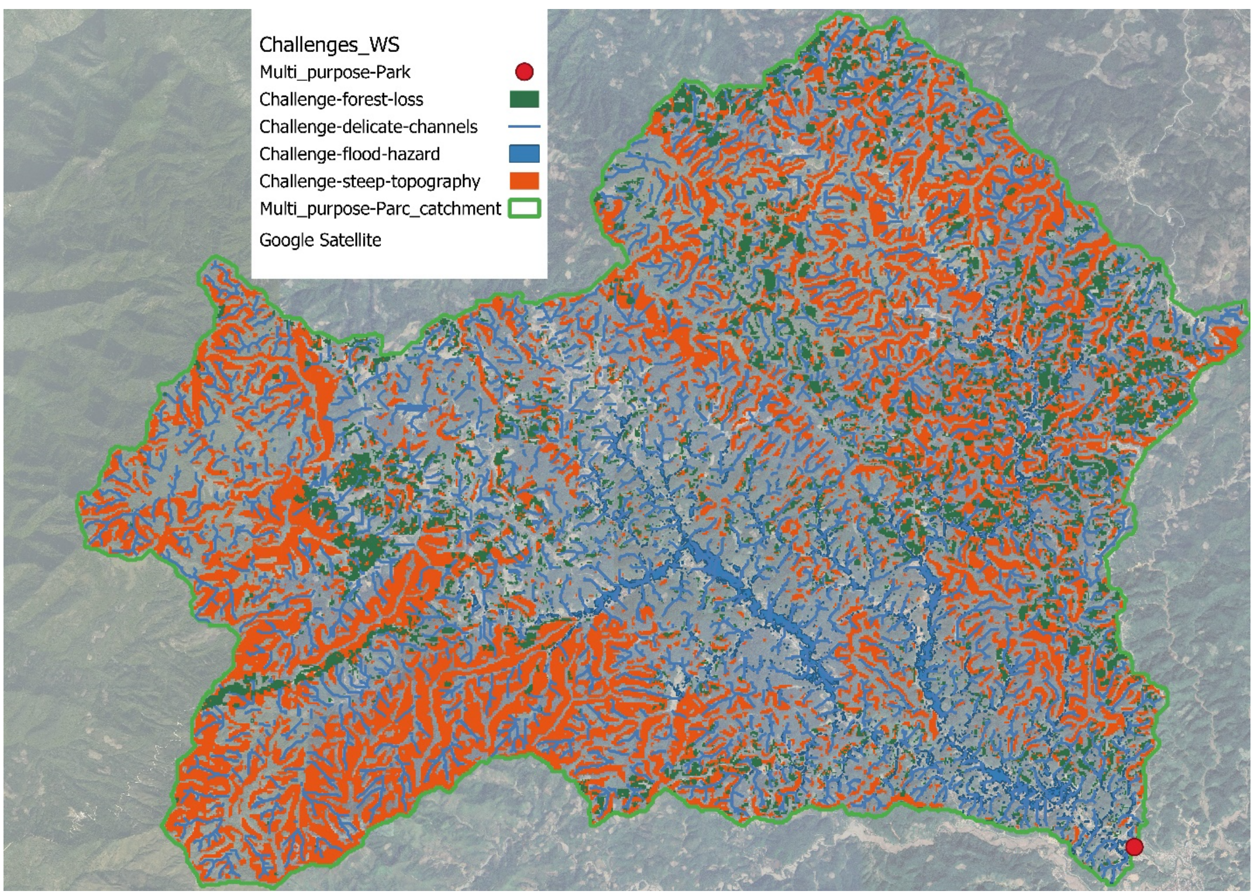
1. Watershed challenges:

Watershed challenge map: https://felt.com/map/Watershed-challenges-p9AMa9ASObQdOl6kD6Rc6hSC?loc=48.1776,11.5169,14z&share=1

a) Forest loss since 2015 in areas steeper than 30 %

b) Topography over 45 % slope and most delicate channels

c) Innundated areas in the main valleys below 1060m.



2. Framing the results from the site assessment of the Orthomosaick, Digital Surface, Multispectral vegetation index and Google earth timelapse:

Vegetation indicators are chosen based on Xue et al 2023[1] Casamitjana et al 2020[2] and Wang et al 2022[3] in addition, interpretational categories where taken from EOS Data Analytics[4]

a) Digital surface Model: Lower surface elevation is played in darker colours, while higher objects are shown in brighter colours. The assessment indicates, the remaining retention area of the natural valley in the park area and opposite of it in a rectangle form, while highlights medium (east & west) and highly filled up areas (northwest and southeast) in the surroundings.
b) Vegetation cover (NDVI): The park and surrounding area show general good vegetation cover, with the exception of the parc centre, central right river bank and eastern slope. This will be further specified with further assessment.
c) Vegetation health (EVI): Higher values represent healthier vegetation, showing that in general the plan health in the park vicinity is good, with the exception of the fishpond, stormwater drainage and a building within the riparian zone on the right bank or the earthen access ramp.
d) Leaf chlorophyll content (NDRE): Indicates plant health, with low values representing bare soil or developing plants, while higher values indicate healthy plants. The imagery suggests that the centre of the park and fragmented parts of its right bank areas do not have high strong vegetation coverage while veins of non-mature vegetation are spread through the park.
e) Water content (NDWI): Higher values indicate a water surface, while lower values indicate dry, non-aqueous surfaces. During the time of image taking the main water content is presented in the river, and small puddles inside the fish pond as well as within the park area or opposite side of the road close to a drainage pipe underneath the road. It has to be mentioned that the reflectance assessment

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[1] Xue, B., Ming, B., Xin, J., Yang, H., Gao, S., Guo, H., ... & Li, S. (2023). Radiometric Correction of Multispectral Field Images Captured under Changing Ambient Light Conditions and Applications in Crop Monitoring. *Drones*, *7*(4), 223.

[2] Casamitjana, M., Torres-Madroñero, M. C., Bernal-Riobo, J., & Varga, D. (2020). Soil moisture analysis by means of multispectral images according to land use and spatial resolution on andosols in the Colombian Andes. *Applied Sciences*, *10*(16), 5540.

[3] Wang, N., Guo, Y., Wei, X., Zhou, M., Wang, H., & Bai, Y. (2022). UAV-based remote sensing using visible and multispectral indices for the estimation of vegetation cover in an oasis of a desert. *Ecological Indicators*, *141*, 109155.

[4] https://eos.com/make-an-analysis/

should be combined with orthomosaick or 360° evlaluation, as some of the artificial surfaces in the image have low reflectance, that is displayed as water surface in this form.

f) Canopy Density (OSAVI): High values indicate denser vegetation, which would support water interception and help to identify areas within the park, riparian area and adjoining areas which may be a focus for restoration as they are currently less dense. Evaluation indicates that in the centre of the park, as well as the first half of the right riparian area have that potential, as well as five smaller fragments on the left side riparian area or the eastern slope of the park head(red). In comparison, the second half, of the riparian zone, as well as the western slope and the southern fiels have higher vegetation density (green), which less restoration priority. This can be visually reviewed in the 360° images.

Land use changes in the natural floodplain around the park

Visual review of Google earth Pro time lapse for the specific valley part where the Multipurpose parc is located show that over the past 10 years, ca. 2/3 of the natural valley floor east of the parc have been filled up, indicating a man-made reduction of retention potential that raises flood hazards for downstream areas even more (Google Earth & Maxar Technologies, CNES/Airbus, 2024). The area lost is approximately 3,8 ha, in a 3m flood scenario, indicated by flood hazard assessment in 2018 on the site of suggested Dedicated flood zones across the river would estimate the volumetric loss of potential on-site retention area to ca. 114.000m3 that is approximately a 3m flood of the entire market area of Sam Neua or ca. 5,5 soccer fields.

Reviewed in webodm (switch between indicators layer)

Orthomoasick: https://cloud1.webodm.net/public/task/0fdc43a3-f75e-4901-9301-8146cd0005aa/map/?t=orthophoto

Multispectral: https://cloud1.webodm.net/public/task/7e2effc0-a5e1-472b-8d32-4d0e1ff501d2/map/?t=plant

Drone images in Felt Map 1: https://felt.com/map/Multipurpose-parc-Drone-images-6HfNJd2uT9CuVejdJN2pgDC?loc=50.9347,6.9878,14z&share=1

3. Contextualize on watershed level (Hydrology /Land Use/ Land cover / Climate /) **Frederic**

Climate:

The study area is located in an area characterized by a tropical climate with two seasons. A dry season between October and May with mean precipitation of 180mm, and a wet season starting April and ends in September with an average precipitation of 1,145 mm. In terms of the occurrence of extreme events in the Nam Xam catchment that encompasses the study area (future park) was prone to several droughts episodes. Based on the analysis of two droughts indicators SPI12 and SPEI12, the longest and most severe drought episodes were recorded between 2010-2015, and 1992-1994. However, based on the analysis of three gricultural drought indices VCI, TCI, VHI episodes of agricultural droughts were few and less severe, which means that the lack of precipitation recorded by the SPI and SPEI indices did not impact severely the vegetation conditions in the watershed.

Historic precipitation trends place the use of the parc as a flood retention area mostly between July and September, in more extreme season between July and September.

Hydrology & Topography analysis catchment upstream of park

The catchment of the area upstream of the parc is 208 km^2 (Sam Neua basin total 418km^2), with average slope of 37% of e.g. most of it is very strong slope according to the slope steepness index, with also indicates that 80 % of the area show a slope of over 30 % in total, indicating high erosion threads, especially in combination with deforestation. A total of 923 km of natural drainage channel are estimated above the park. The analysis is based on FABDEM+ (Hawker et al 2023[5])

Topography and catchment information can be reviewed on felt map 2: https://felt.com/map/Contextualization-Hydrology-RjnE7rimRdS7n4IAp9BXNjA?loc=20.4611,103.95051,11.84z&share=1

Land cover / Land use change assessment of park catchment:

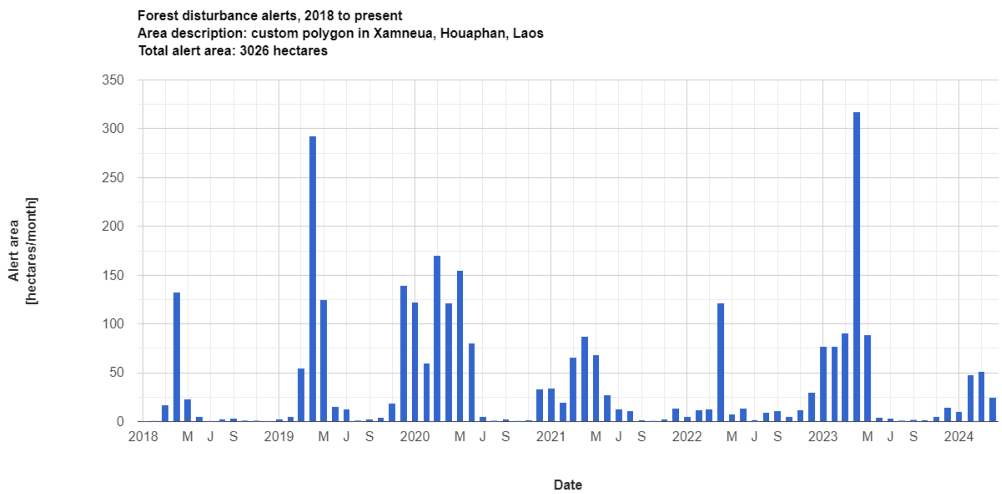
The most current land cover product from the ESA reveals the following percentages of land cover for the upstream areas from the park: 84,54 % Tree cover, 11,32% Grassland, 4,12 % Cropland and below 1 % Built up, Bare and permanent water bodies (Zanaga et al 2023[6]). The areas where grassland is present overlay largely with areas where primary forest was lost since 2015, which reveal a decrease in tree cover of estimated 8% or 6,07 km2, compared to an estimated total of 21% or 15,8 km2 since 2000. In 2023, ca 1,7 % or

[5] Hawker, L., Uhe, P., Paulo, L., Sosa, J., Savage, J., Sampson, C., & Neal, J. (2022). A 30 m global map of elevation with forests and buildings removed. *Environmental Research Letters*, *17*(2), 024016.Data downloaded from FABDEM V1-2 - Datasets - data.bris, DOI: 10.5523/bris.s5hqmjcdj8yo2ibzi9b4ew3sn

[6] For methology see , data donloaded from WorldCover Viewer (esa-worldcover.org)

1,3km2 of primary forest lost / changed tree cover (GFW- optical data[7]). Based on the GWF dataset review, the used dataset Hansen Global Forest Change v1.11 (2000-2023) was clipped to the watershed an downloaded from Google earth engine, the data was then filtered by the years 205- 2023 and clipped with slopes above 20 % in order to define a challenge area.

To identify the human activity within the catchment, radar based land use alerts (LUCA) provided by CTrees[8] are used, which estimates a total of 30,26 km2 or 14,5% of the area has been affected by human activity since 2018, with 6,58km2 or 3,2% in 2023.General activity outlines a regular peak of activity in the late dry season months of April.



Analysis on NDVI composites from 2020 and 2021 show that cropland development and urbanization seem to follow mostly main river channels, while deforestation is present in more remote, and slightly steeper areas. (See https://bit.ly/3Q75c5f or felt map 3)

This is relevant to consider future trends, which would effect the flood water that is drain from the basin to the park and influence its effectiveness to retend flood water or potential loss of structures. Areas of importance are specifically 10 km north and 15 km west of the park location (marked in Felt map 2).

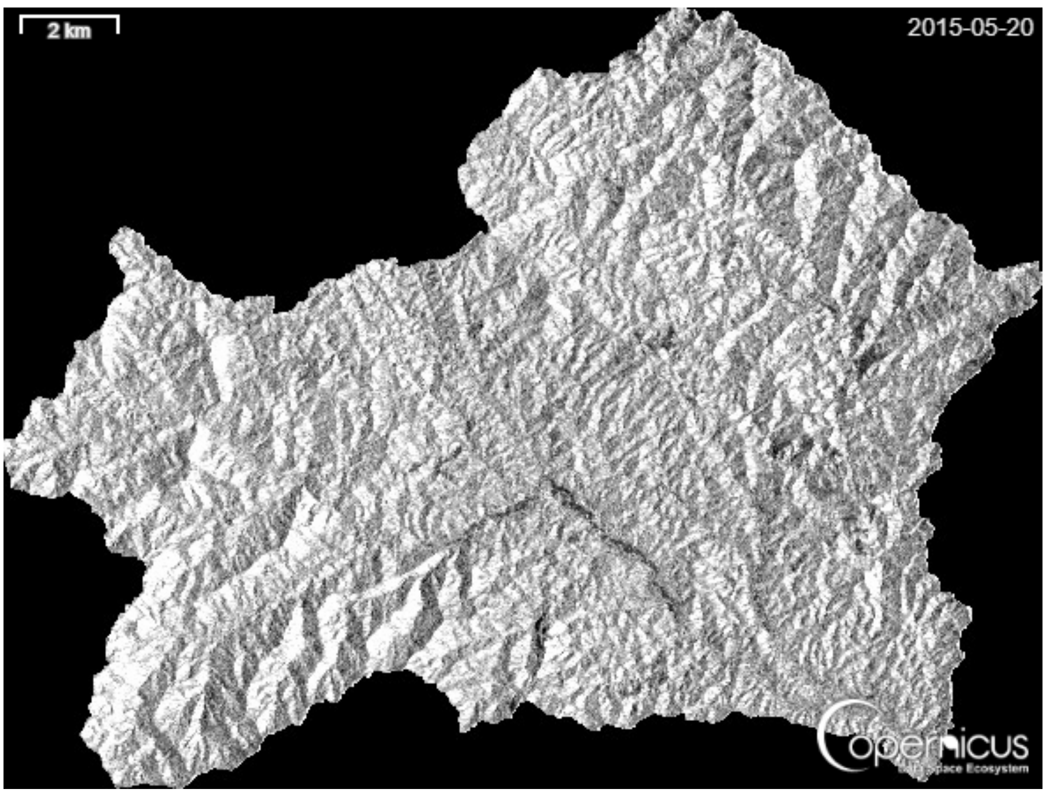
Primary forest loss trends can be viewed at: https://gfw.global/3Q5D3eM

[7] For methodology see High-Resolution Global Maps of 21st-Century Forest Cover Change | Science Data derived from Area in Xam Neua District, Houaphanh, Laos Interactive Forest Map & Tree Cover Change Data | GFW (globalforestwatch.org)
[8] For methodology see CTrees Data derived from CTrees

Lancover and Slopeand NDVI composite Information can be reviewed on felt Map 3: https://felt.com/map/Contextualization-Land-cover-use-change-igSqOWEAT8aWZZ6Unc19CMB?loc=20.47635,103.9145,12.03z&share=1

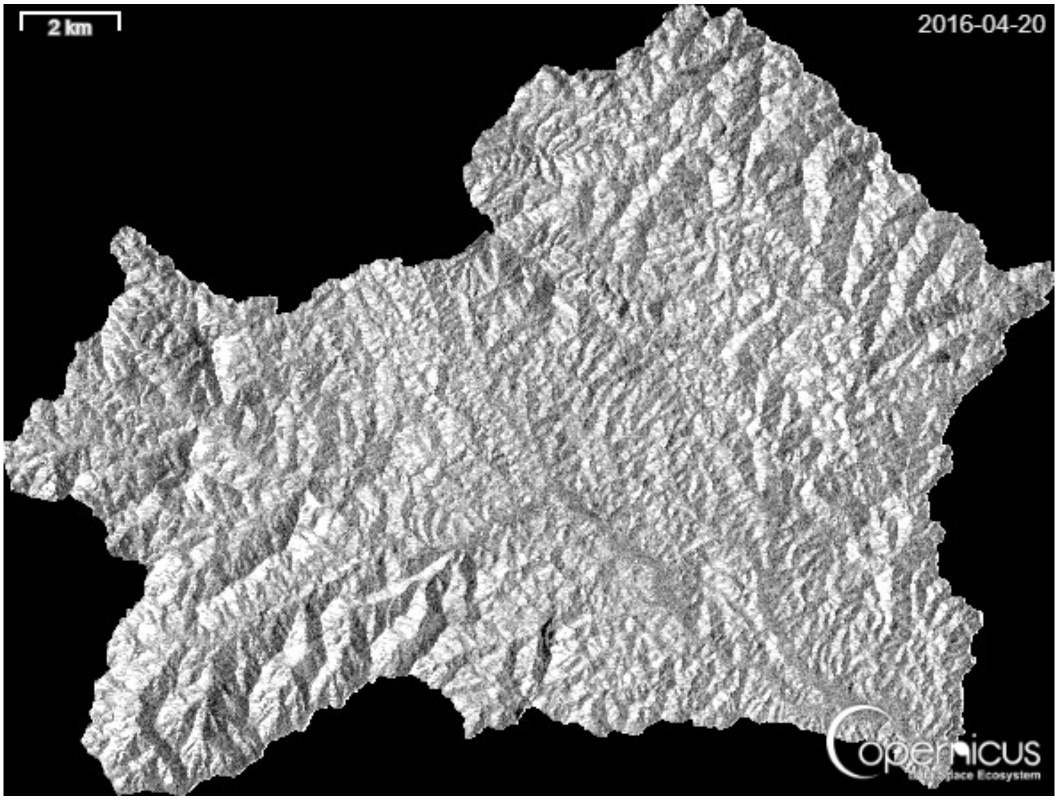
Flood hazard assessment

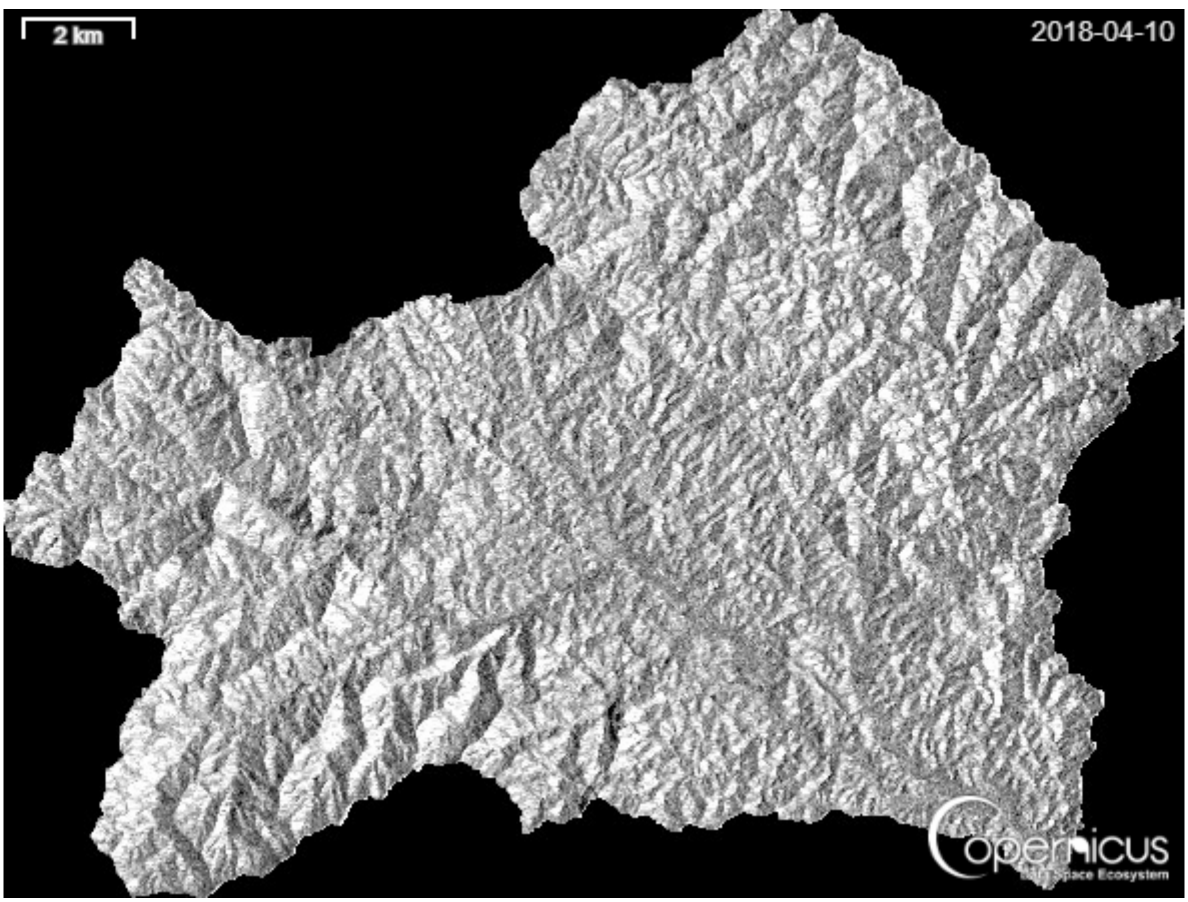
Based on Extreme precipitation event estimation (MSWEPv2.8 1997-2019) (6/20/2015 – Consecutive 5day duration rainfall, 6/24/2015 - 171mm , 5/23/2016 - 62mm) inundation was identified with the available timeframe of events in the Copernicus browser[9] (water reflectance in black) and then processed Sentinel 1 images (aligned with Kiran et al 2019[10]) for 06/2015, 05/2016 and the 2018 season (reported heavy flooding around the park):



[9] Copernicus Browser

[10] Kiran, K. S., Manjusree, P., & Viswanadham, M. (2019). Sentinel-1 SAR data preparation for extraction of flood footprints-A case study. *Disaster Advances*, *12*(12), 10-20.


2 km
2016-04-20
Copernicus


2 km
2018-04-10
Copernicus

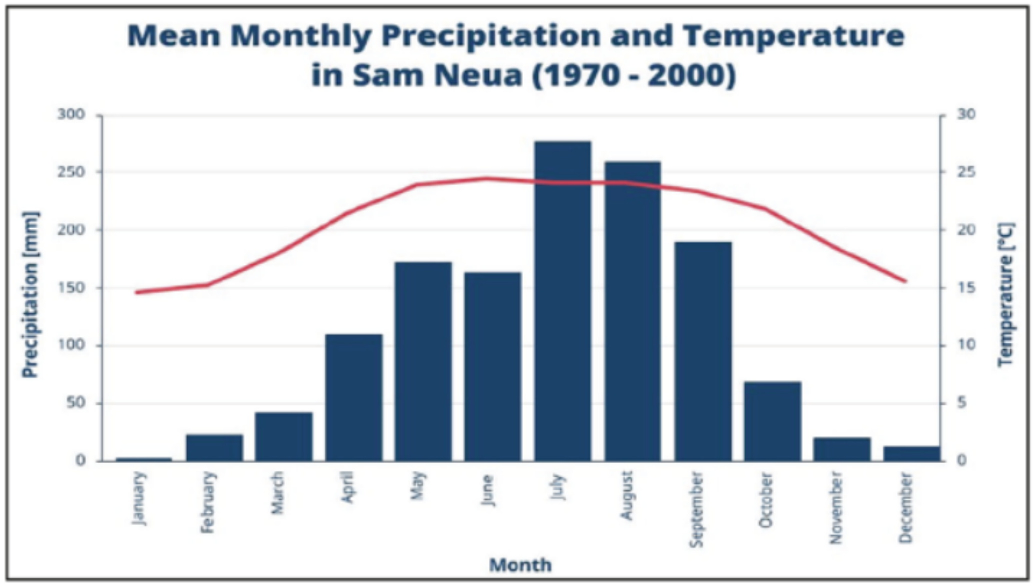
The available images indicate flooding upstream of the park in 2015, along the southwestern and northeastern parts of Nam Xam, with similar indicator for the time frame 2016. The park area specifically in 2018 seems to have been flooded for a short period around 24th of June with an estimated delayed response time from upstream areas (flooded during late May to Early June). However, it must be noted that due to the nature of the topography, SAR based estimations are limited in a mountainous area in general and narrow valleys, such as where the park is located in. However, is as inundated identified areas are overlayed with low elevation of the valley floor, this provides a better indication. Destinctively the 2018 observation does not correlate with the most extreme weather events, indicating a potential more important role of land use change to this event.

In order to remove SAR based bisases created from the mountains, the overall identified areas of no retun signal were clipped with available information of slope steepness and clipped by areas of steepness over 20%.

Processed Flood hazard assessment can be reviewed in felt map 4: https://felt.com/map/Contextualization-Flood-hazard-assessment-Vq9COx8lASbiik0Zmj4Kt6C?loc=50.9347,6.9878,14z&share=1

Climate and future scenarios:

Historic precipitation trends place the use of the parc as a flood retention area mostly between July and September, in more extreme season between April and September, with



IPCC

Overall and considering most of the IPCC scenarios, the Sam Neua village will know an increase in both total annual precipitation and mean temperature.

Scenarios		Total annual precipitation		mean temperature	
		Sam Neua		Sam Neua	
		% change	Value (mm/day)	% change	Value (°C)
SSP5- 8.5	Near term (2021-2040)	2.02	4.11	1.13	21.74
	Medium term (2041-2060)	**4.70**	**4.11**	**1.13**	**22.77**
	Long term (2081-2100)	10.98	4.22	4.63	25.23
	Warming 1.5°C	2.07	4.11	1.08	21.68
	Warming 2°C	3.48	4.17	1.08	22.17
	Warming 3°C	6.99	4.31	2.68	23.29
	Warming 4°C	6.99	4.13	3.80	24.46
SSP3- 7.0	Near term (2021-2040)	- 1.22	4.10	0.90	21.45
	Medium term (2041-2060)	**1.29**	**4.21**	**1.62**	**22.16**
	Long term (2081-2100)	5.68	4.38	3.43	23.97
	Warming 1.5°C	- 1.27	4.10	0.94	21.48
	Warming 2°C	1.55	4.22	1.39	21.93
	Warming 3°C	2.99	4.34	2.38	21.93
SSP2-4.5	Near term (2021-2040)	1.21	4.11	1.04	21.66
	Medium term (2041-2060)	**4.11**	**4.23**	**1.66**	**22.28**
	Long term (2081-2100)	6.14	4.31	2.60	23.23

Scenarios		Total annual precipitation		mean temperature	
		Sam Neua		Sam Neua	
		% change	Value (mm/day)	% change	Value (°C)
	Warming 1.5°C	1.20	4.11	1.06	21.68
	Warming 2°C	4.11	4.23	1.57	22.19
SSP1-2.6	Near term (2021-2040)	2.94	4.22	1.10	21.73
	Medium term (2041-2060)	**5.96**	**4.34**	**1.10**	**22.14**
	Long term (2081-2100)	8.03	4.42	1.62	22.25
	Warming 1.5°C	3.31	4.42	1.03	21.68

Historical, Wordlclim and Cordex

Results of precipitation previsions from two different products show that based on the WorldClim previsions; there is a slight and minor decrease in the total annual precipitation over the medium term and based on the SSP2 comparing the historical data from Chirps. The highest and most considerable changes where noticed in the dry season months.

For the CORDEX products that has a coarse resolution, results show a huge increase in the precipitation on an annual base and also monthly.

	Chirps 1981-2021 (Historical)	WordClim 2041-2060 SSP2-4.5	Change WorldClim to historical	Cordex RCP4.5 -2021-2050	Change Cordex to Historical
January	1.92	2.26	18%	5.29	176%
February	18.94	20.38	8%	33.83	79%
March	52.59	47.07	-10%	53.78	2%
April	108.62	100.15	-8%	122.17	12%
May	182.50	174.39	-4%	274.57	50%
June	138.08	137.35	-1%	188.17	36%
July	277.66	272.66	-2%	405.86	46%
August	248.32	246.25	-1%	340.55	37%
September	179.56	193.98	8%	130.92	-27%
October	76.17	76.31	0%	90.79	19%
November	15.66	15.382	-2%	20.22	29%
December	11.95	10.64	-11%	17.31	45%
Total annual	1,311.97	1,296.86	**-1%**	1,683.46	**28%**