Lessons from Piloting Monitoring & Evaluation of Ecosystem-based Adaptation in Thailand's Water Sector

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Prepared by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) for the Joint Research Partnership to Advance Ecosystem-based Adaptation in the Thai Water Sector, within the collaboration under the Thai-German Climate Programme-Water, supported by the International Climate Initiative (IKI) of the German Federal Government.

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Acronyms & abbreviations

BMWP	Biological Monitoring Working Party
CBA	Cost-benefit Analysis
CBR	Cost-benefit Ratio
EbA	Ecosystem-based Adaptation
GISTDA	Geo-Informatics and Space Technology Development Agency
GIZ	Gesellschaft für Internationale Zusammenarbeit GmbH
GRACE	Gravity Recovery and Climate Experiment
IUCN	International Union for the Conservation of Nature
JRP	Joint Research Partnership to Advance Ecosystem-based Adaptation in the Thai Water Sector
M&E	Monitoring and Evaluation
NbS	Nature-based Solutions
NDC	Nationally Determined Contribution
ONWR	Office of the Natural Water Resources
RID	Royal Irrigation Department
ToC	Theory of Change
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
WTC	Willingness to Contribute

Executive summary

This report is a synthesis of the findings and recommendations generated by two research projects **piloting monitoring and evaluation (M&E) approaches for Ecosystem-based Adaptation (EbA) measures** in the water sector of Thailand. Under the umbrella of the Joint Research Partnership to Advance Ecosystem-based Adaptation in the Thai Water Sector (JRP), an initiative by the Office of the National Water Resources (ONWR) and GIZ, five Thai universities, working in two teams, carried out parallel pilot studies to generate evidence on the impacts of EbA in the Thai water sector and to test the development of M&E approaches.[1]

EbA, and other types of Nature-based Solutions (NbS), are **increasingly being integrated into adaptation plans and strategies** around the world, including in Thailand. Thailand is among the world's most vulnerable countries to the impacts of climate change, and is in the top ten countries affected by extreme weather.[2] EbA is mentioned in Thailand's Nationally Determined Contribution (NDC) (2020-2037)[3], and in the country's NDC Roadmap 2021-2030.[4] However, there is untapped potential (NDC) to scale up EbA measures in the country's water sector and beyond.

Based on best practices for M&E of EbA, such as the "Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions", the pilot studies adapted a step-by-step process to develop and apply M&E approaches for EbA. These studies examined two different types of existing ecosystem-based measures aimed at reducing the impacts of flooding and water shortages in two sites in Thailand:

I. Natural and semi-natural **flood retention areas** in the lower Yom river basin;
II. **Living weirs** at two pilot sites on the Khlong-La river, Songkhla province, and Khlong Wang Heep, Nakhon Si Thammarat province.

With a focus on testing digital solutions and participatory approaches for the M&E of EbA, the university teams followed four key steps:

Step 1. Developing a Theory of Change (ToC) for the existing EbA measures, focused on defining key outputs, outcomes and impact, to inform the development of the M&E approach;

Step 2. Defining and refining indicators, focused on assessing the hydrological, environmental and socio-economic impacts of the EbA measures, linked back to the ToC;

Step 3. Operationalizing the M&E approaches, by defining methods to assess the indicators and carrying out data collection and analysis, making use of digital solutions and participatory approaches;

Step 4. Communicating results back to stakeholders in the pilot areas and preparing reports and briefings for policy-makers.

[1] The five university partners, Chulalongkorn University, Naresuan University, Mahidol University, Prince of Songkla University, and Walailak University, carried out the pilot studies. The JRP is an initiative under the Thai-German Climate Programme-Water, implemented by the German Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German federal Government. The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) provided technical support to the pilot studies.

[2] The 10 countries most affected 2000 – 2019 (annual averages), see: https://www.germanwatch.org/sites/germanwatch.org/files/2021-01/cri-2021_table_10_countries_most_affected_from_2000_to_2019.jpg

[3] ONEP, MONRE (2020) Thailand's Updated Nationally Determined Contribution. https://unfccc.int/sites/default/files/NDC/2022-06/Thailand%20Updated%20NDC.pdf

[4] ONEP, MONRE (2017) Thailand's NDC Roadmap on Mitigation (2021 – 2030).

Key messages from the pilot studies

- Monitoring and evaluation (M&E) is essential for effective EbA; it supports the communication of M&E results as well as adaptive management of EbA measures.
- M&E is a continuous process that begins at the design stage of EbA, with tools like Theory of Change supporting both the design of effective EbA measures and development of M&E frameworks. M&E thus needs to be planned and budgeted for throughout the lifetime of EbA measures.
- M&E for EbA can use a variety of approaches and methodologies, from drawing on existing data and monitoring processes, to digital technologies, qualitative studies, and participatory M&E.
- The piloting of M&E approaches by universities and government agencies has provided a better understanding of the impacts of selected EbA measures and strengthened the design of M&E for EbA in Thailand's water sector.
- The two pilot studies show that ecosystem-based water management and adaptation measures like living weirs and natural floodplains can reduce risks from flood and droughts, and provide environmental and socio-economic benefits to local communities, though there are also trade-offs.
- The pilots also demonstrate that methods ranging from simple water level measurements and water quality sampling, to hydrological modelling and use of drones, as well as community participation and household surveying, can help to support long-term EbA M&E in Thailand.
- Participatory approaches are particularly valuable for informing the design and implementation of M&E, and allow communities to better understand the impacts of ecosystem-based water management measures, and contribute to the adaptive management of EbA in the future.

The two EbA M&E pilot studies started in 2020 and continued during 2021-2022; the COVID-19 pandemic as well as flooding in the wet season posed some challenges for the teams. Despite these challenges, the studies have generated valuable information on the impacts of the EbA measures , as well as insights on how to apply M&E methods, and when and where these methods may be most appropriate. They have also demonstrated that the two EbA measures (living weirs and floodplain detention schemes) deliver both benefits and trade-offs. The full range of benefits and trade-offs of EbA measures should be assessed to inform adaptive management and improve EbA into the future. Please see **Key Messages** and the table below **summarizing the impacts** observed for the two EbA measures.

Hydrological impacts	Environmental impacts	Socio-economic impacts
LIVING WEIRS		
+ Water retention in upstream areas increased in both sites, potentially **helping to reduce water shortages** in dry periods	+ Positive impacts on habitat for aquatic insects fish, molluscs and decapods	+ **Participation** of some community members and **governance** related to living weirs / water management are strengthened
+ Some **slowing of water flow** in times of heavy rainfall at both sites	••• No impact observed on water quality	+ Numerous households gain **direct and indirect benefits** both upstream and downstream for domestic & agricultural water use and recreation
+ ••• **Sub-surface water level and soil moisture content** appears to slightly increase near living weirs in dry periods (site A). This increase is more pronounced upstream but more observation is needed	••• + No impact observed for bat diversity (neutral) and mosquito abundance (benefit for health & wellbeing)	+ **Cultural and leisure activities** around living weirs sites are increased though fishing remained the same

Hydrological impacts	Environmental impacts	Socio-economic impacts
FLOODPLAINS		
+ Mitigation of **flood impacts** in the Yom river basin	– Some evidence of **decreased fish abundance** downstream of the flood detention area	+ **Income from fisheries and aquaculture** during flooded period within the detention area
+ Evidence that the flood detention area could **enhance groundwater recharge**	– **Reduced flood** in bypassed areas may lead to changes in physical and biological characteristics of riverine ecosystems	+ **Income from agriculture** in the dry season in flood detention area
– **Fragmentation** between river and floodplain disconnecting some areas from flood pulse	– **Fragmentation** of some areas of the floodplain may affect ecological processes that support ecosystem functions	– **Livelihoods of farmers and fishers** reliant on areas outside of the flood detention area negatively impacted
		– **Loss of rice cultivation** in the flood detention area during flooded period

Recommendations have also been put forward for the consideration of policy makers and EbA practitioners in Thailand. These recommendations relate to the future application of M&E for EbA in Thailand's water sector, as well as to the future promotion of EbA more broadly.

Recommendations on M&E of EbA:

- M&E frameworks for EbA should be developed through **robust approaches**, like Theory of Change, with stakeholder and expert involvement.
- M&E frameworks (comprising elements like Theory of Change and indicator sets) for EbA measures need to be **comprehensive but manageable**, and local perspectives can help achieve this, by focusing on important concerns and desired benefits.
- Specific attention is needed for **gender-responsive M&E frameworks**, including components such as indicators that examine different vulnerabilities of all genders, different benefits and costs experienced, participatory approaches, and gender disaggregation of data.

- **Contextual information for M&E** is essential, including aspects such as climate, disaster, land use and socio-economic trends; collection of this information needs to be included in M&E frameworks from an early stage, in order to understand how EbA measures are performing in the local context.
- Valuable insights can be gained from **examining comparisons or scenarios** between EbA and business-as-usual or other types of interventions (e.g. concrete measures), highlighting the value of EbA, or where EbA measures could be usefully combined with other types of measures.
- Data collection and analysis can be **resource- and time-intensive**, but there are ways to minimize these challenges, such as collaboration with universities, students and local communities, and automated systems.
- Thailand's M&E approaches need to be tailored to examine impacts in both **wet and dry seasons**, considering not just data collection but also which costs and benefits are generated in different seasons.
- **Digital technologies**, like remote sensing, offer relatively low-cost methods to support M&E, but also challenges, such as the need for expertise, equipment and long-term, accurate data (e.g. for modelling).
- **Online applications** supporting community participation and citizen science can also enable data collection, but require quality control, long-term participation and ensuring the usefulness of the data to the users.
- **Participatory approaches for M&E** are valuable for strengthening M&E design and implementation, and are more than a means to an end; participation in design and implementation of EbA measures, including M&E, is a basic right that should be offered to communities and other stakeholders.
- A **range of participation types** can help achieve different goals for EbA M&E, from sharing information with stakeholders to enabling participation in data collection and evaluation, while also addressing M&E challenges, such as securing longer-term engagement.
- Where possible, M&E for EbA should link to, and integrate with, **other relevant data and monitoring systems** (e.g. wider river basin management monitoring, national adaptation monitoring).
- The information collected through M&E **has multiple uses**; linking M&E to a range of users, including government, communities, private sector, and to uses beyond EbA, may strengthen the commitment to M&E.
- **Sharing the results of M&E** can provide a forum for discussing concerns and strengthening EbA, supporting adaptive management of EbA measures and identification of solutions to challenges.
- M&E strengthens the evidence base for EbA, shows how EbA measures are performing in different contexts, and highlights challenges that may need to be addressed. To better support future decision-making, a **full picture of the range of benefits of EbA** is needed, along with full transparency on trade-offs, providing valuable information for deciding which options will work best for communities, the economy and ecosystems.

Recommendations for scaling up EbA

- **EbA opportunity mapping** (combining spatial information on climate change risks, ecosystem services, communities, etc.) can help to identify priority geographical areas for EbA, as well as options for how EbA could be located and designed to promote multiple benefits.
- **Local participation in EbA** can increase support for it, improve awareness of integrated water management (IWRM) and disaster risk reduction, and strengthen long-term effectiveness, but targeted mechanisms and platforms are needed, such as enabling river basin communities (RBCs) to consider and promote EbA, along with dedicated support and capacity building.
- **Local knowledge, expertise and creativity** should be integrated into the design, implementation and monitoring of EbA, involving local communities and other stakeholders in identifying challenges and solutions, designing EbA measures to increase positive impacts and reduce negative impacts, and formulating appropriate M&E frameworks.
- Design and implementation of EbA should seek to **generate different types of benefits at multiple levels**, from households to communities, and the country as a whole. Interventions that do not deliver sufficient benefits and manage costs or trade-offs are unlikely to be sustainable over long-term or to achieve their core objective: resilience for people and ecosystems.
- Various tools and approaches are available to gain a more comprehensive **understanding of the potential costs and benefits of EbA** and integrate these into decision-making and planning, such as participatory assessment, ecosystem valuation, and natural capital and water accounting.
- EbA can have far-reaching impacts on ecosystems and communities, both positive and negative, and thus **technical standards and safeguards** should be applied to guide EbA design, implementation and evaluation, to help ensure that measures are effective, respect the rights of local communities, protect biodiversity, and are more likely to deliver benefits.

This paper is based on the results of the two pilot projects under the JRP,

i. Developing M&E for living weirs by Prince of Songkhla University and Walailak University, and
ii. Developing M&E for Floodplains by Chulalongkorn University, Mahidol University and Naresuan University.

1
Introduction

This report presents a synthesis of the findings and recommendations generated by two pilot projects to develop approaches for the monitoring and evaluation (M&E) of ecosystem-based adaptation measures in the water sector of Thailand. The cooperation was set up under the Joint Research Partnership to Advance Ecosystem-based Adaptation in the Thai Water Sector, and the two pilot projects were implemented by the university teams (see Box 1).

Box 1: Joint Research Partnership to Advance Ecosystem-based Adaptation (EbA) in the Thai Water Sector

Established in 2020, the Joint Research Partnership (JRP) is an initiative of the Office of the National Water Resources (ONWR), five Thai universities – Chulalongkorn University, Naresuan University, Mahidol University, Prince of Songkla University, and Walailak University – and the German international cooperation agency, the Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, to generate evidence and improve knowledge of the benefits of ecosystem-based adaptation in the Thai water sector.

The JRP has three main goals:

1. to provide evidence on the impacts and benefits as well as the limitations of EbA measures for reducing flood and drought risks and increasing water security;
2. to use digital-based methods for data collection and monitoring, and include local communities and local knowledge in the application of M&E;
3. to link technological skills, M&E knowledge, and data products to river basin, national water data management and climate change reporting frameworks.

The JRP is cross-sectoral, made up of ONWR, the universities and representatives from a range of Thailand government agencies, including but not limited to the Royal Irrigation Department, Royal Forest Department, Land Development Department, Office of Natural Resources and Environmental Policy and Planning, and relevant provincial governors.

Background: Ecosystem-based Adaptation

Nature-based Solutions (NbS) acts as an umbrella term for a wide range of more specific approaches that all use approaches for managing, restoring or protecting ecosystems to address societal challenges (see Figure 1). This report will focus on Ecosystem-based Adaptation (EbA), a type of NbS designed to tackle climate change induced threats. IUCN has defined NbS as "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".[5]

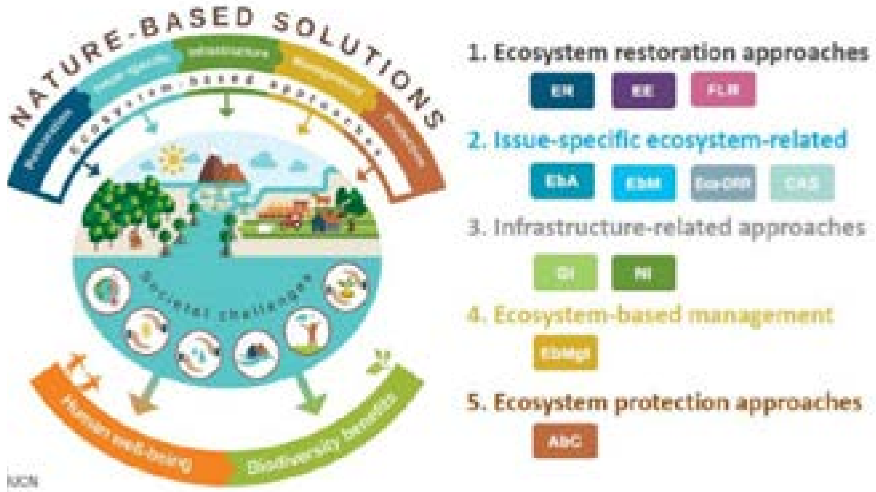


Figure 1: Nature-base solutions as an umbrella for a variety of ecosystem-based approaches[6]

Ecosystem-base adaptation (EbA) is defined by the Secretariat of the United Nations Convention on Biological Diversity as follows:

"Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change."[7]

Based on this definition, EbA is a human-centered approach that uses the conservation, sustainable management and restoration of ecosystems to **maintain or enhance ecosystem services that support people to adapt to the impacts of climate change**. EbA measures aim to **maintain and increase the resilience of ecosystems and people to the adverse effects of climate change**, for example by reducing their exposure, sensitivity and/or vulnerability.

EbA measures can be implemented in a **wide variety of ecosystems and contexts**, and are a means of adaptation available to rural and urban areas, and applicable in different sectors and contexts. EbA also overlaps with other key sustainable development, environmental and climate change strategies, such as community-based adaptation and biodiversity conservation (see Figure 2 below).

[5] IUCN (2016) World Conservation Congress. Resolution 069. Defining Nature-based Solutions. https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_069_EN.pdf

[6] IUCN (2020) Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN.

[7] Secretariat of the Convention on Biological Diversity (2009) Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Montreal, Technical Series No. 41, https://www.cbd.int/doc/publications/cbd-ts-41-en.pdf

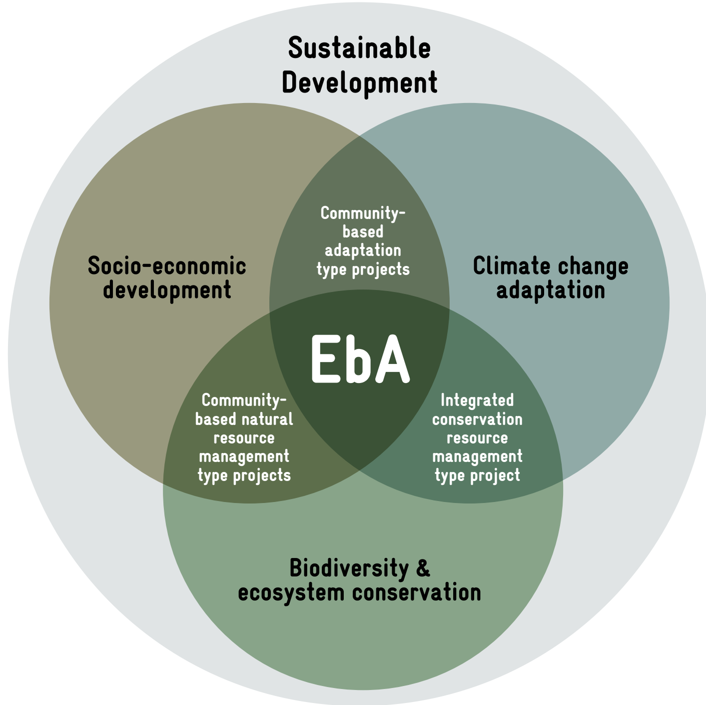


Figure 2: Interlinkages between EbA and other approaches[8]

In addition to addressing climate change impacts[9], EbA measures also offer a range of **social, economic, environmental and cultural co-benefits**. The benefits generated by EbA will depend on the context and the EbA measure being applied, but can include:

- Promotion of traditional knowledge and practices
- Strengthened governance of natural resources
- Improved conservation of biodiversity, such as habitats and threatened species of wildlife
- Enhanced carbon storage for climate change mitigation
- Support for local livelihoods
- Benefits for human health and wellbeing

EbA, and other types of Nature-based Solutions (NbS), are increasingly being **integrated into adaptation plans and strategies**, and increasingly implemented in countries across the world. For example, around 66% of the Paris Agreement signatory countries included Nature-based Solutions (like EbA) in their plans for achieving their climate change mitigation and/or adaptation goals,[10] and with the latest round of Nationally Determined Contributions (NDC), most include adaptation actions aligned with nature-based approaches, such as increasing the connectivity of protected areas, restoring degraded ecosystems, and promoting sustainable forest management practices.[11] In this context, 80% of Parties mentioned freshwater resources, and around 70% mentioned terrestrial and wetland ecosystems.

[8] Adapted from Midgley et al. 2012, in GIZ, UNEP-WCMC and FEBA (2020) Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn, Germany.

[9] Chausson et al. (2020) Mapping the effectiveness of Nature-based Solutions for climate change adaptation. Global Change Biology, vol. 26, issue 11, https://doi.org/10.1111/gcb.15310

[10] Scolobig, A. et al. (2021) The role of public and private sectors in mainstreaming Nature-based Solutions. Background document for Del. 5.2. and 5.3. of the PHUSICOS project, According to nature. Nature based solutions to reduce risks in mountain landscapes, EC H2020 Programme.https://phusicos.eu/wp-content/uploads/2019/01/PBF2_Synthesis.pdf

[11] UNFCCC (2021) Nationally determined contributions under the Paris Agreement - Synthesis report by the Secretariat. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf

Integration of EbA into policy and practice in Thailand

Thailand is among the world's most vulnerable countries to the impacts of climate change, and is in the top ten countries affected by extreme weather.[12] EbA is increasingly present in policy and practice in Thailand. For example, it is mentioned in Thailand's **Nationally Determined Contribution** (2020-2037)[13], submitted to the UNFCCC in 2020, although target ecosystems and actions for EbA are not specified. Thailand's NDC Roadmap 2021-2030[14] lists a number of adaptation efforts related to ecosystems including protection, sustainable management and rehabilitation of ecosystems, such as: "increasing forest cover to 40% through local community participation, including in particular headwater and mangrove forests to enhance adaptive capacities of related ecosystems". Thailand's **National Adaptation Plan** (2018-2037)[15] targets the six priority sectors of water resources management (agriculture and food security, tourism, public health, natural resources management and human settlements and security), and highlights the potential for the sustainable management of natural resources and biodiversity to support adaptation to climate change.

In the **water sector** – although historically the country has relied on "grey" infrastructure – EbA is increasingly attracting attention from the Office of National Water Resources (ONWR) as well as other policy-makers and practitioners, as an option to reduce the adverse hydrological impacts of climate change and disasters and promote sustainable development. This can include EbA measures such as wetlands protection and rehabilitation, watershed forest management and restoration, as well as "grey-green" solutions (which combine EbA with more traditional, engineered infrastructure approaches). For example, although **Thailand's 20-Year Water Management Master Plan** (2018-2037)[16] does not explicitly mention EbA, it states the need for conservation and restoration of watershed forests, particularly in areas that experience frequent drought and flooding. In addition, ONWR through its collaboration with GIZ and other partners has developed a "Guidebook for the Design and Implementation of Ecosystem-based Adaptation in River Basins in Thailand" linking EbA with climate-sensitive Integrated Water Resources management (climate-sensitive IWRM) for Thailand's 22 river basins.[17]

A range of criteria and best practices inform the development and implementation of effective EbA measures. These good practices are covered in resources developed under the collaboration of ONWR, GIZ and other partners, such as the above-mentioned "Guidebook for the Design and Implementation of Ecosystem-based Adaptation in River Basins in Thailand", as well as the EbA Code of Practice Compendium and a toolbox with e-learning materials on EbA for the Thai water sector (available on the online learning platform Atingi). Robust **monitoring and evaluation (M&E)** is one of the essential elements for effective EbA, and is the focus of this report.

[12] The 10 countries most affected 2000 – 2019 (annual averages). See: https://www.germanwatch.org/sites/germanwatch.org/files/2021-01/cri-2021_table_10_countries_most_affected_from_2000_to_2019.jpg

[13] ONEP, MONRE (2020) Thailand's Updated Nationally Determined Contribution. https://unfccc.int/sites/default/files/NDC/2022-06/Thailand%20Updated%20NDC.pdf

[14] ONEP, MONRE (2017) Thailand's NDC Roadmap on Mitigation (2021 – 2030).

[15] Thailand National Adaptation Plan, available at: http://t-plat.deqp.go.th/en/nap-0-en/nap-en-main/

[16] Thailand's 20-Year Water Management Master Plan (2018-2037), available at: http://www.onwr.go.th/en/?page_id=3824

[17] Decree for the Establishment of River Basins 2021 (B.E.2564) under the Water Act 2018 (B.E.2561).

Piloting M&E of EbA for two EbA measures in Thailand

ONWR, in close cooperation with the Thai-German Climate Programme – Water (known as TGCP-Water), initiated a Joint Research Partnership (JRP) with five Thai universities to develop and pilot methodologies for M&E of EbA to provide evidence on EbA effectiveness and inform future M&E efforts. M&E methodologies were developed for two different types of existing ecosystem-based flood and drought mitigation measures:

I. Natural and semi-natural **flood retention areas** in the lower Yom river basin;
II. **Living weirs** at two pilot sites on the Khlong-La river, Songkhla province, and Khlong Wang Heep, Nakhon Si Thammarat province.

Figure 3 below shows the location of the pilot sites.

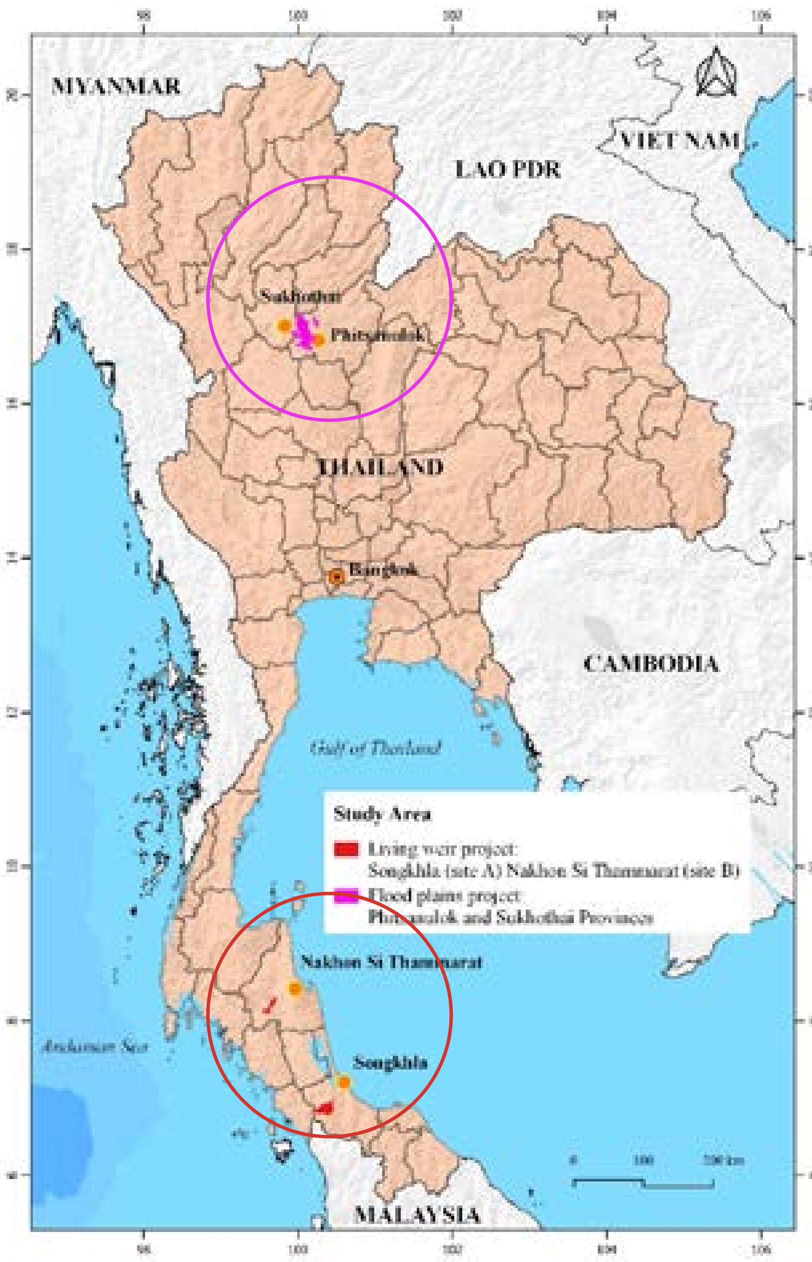


Figure 3: Map of living weirs and floodplain project areas

In line with the "Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions"[18], the two teams developed M&E approaches tailored to the EbA measures and locations being studied, with emphasis on how to integrate digital solutions and strengthen community participation in the M&E of the EbA measure. Key elements included development of an M&E framework, made up of a **Theory of Change** (ToC) and a set of indicators. A ToC is an essential preparatory process for robust M&E. The ToC forms the basis for defining a **set of indicators**; indicators were developed by the teams, linking back to their ToC. These indicators aimed to assess the hydrological, socio-economic, and environmental impacts of the measures. (See Section 2 below for more information on the process to develop M&E frameworks, including ToC).

The teams tested a range of methods as they applied their pilot M&E frameworks, including but not limited to field measurements, hydrological modelling, remote sensing including use of drones, mobile applications for data collection, biodiversity surveying, household surveys and community meetings. The participation of communities and other stakeholders formed an important element, from consultations through to active participation of community members in M&E activities.

This report

This report provides an introduction to M&E for EbA and a synthesis of the lessons gained from the pilot M&E activities in Thailand. Based on the materials developed and results documented by the two teams, this report sets out the following:

- An introduction to **key steps and best practices** for M&E of EbA
- An **overview of the piloting** itself, including the pilot sites and their climate change contexts, the EbA measures considered, the steps followed by the teams to develop and apply their M&E frameworks, and the methods that were tested
- The **results of the pilot studies**, focusing on the impacts of the EbA measures in the sites, and the utility of the M&E methods
- A discussion of the **key lessons learned** from the pilots, particularly with view to any future efforts to promote the uptake of EbA and to strengthen the M&E of EbA in the Thai water sector:

[18] GIZ, UNEP-WCMC and FEBA (2020) Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn, Germany.

2

Monitoring and Evaluation for EbA

M&E is critical to the successful management of any intervention or measure, including EbA. **Monitoring** is the process of systematic observation through the collection and analysis of information over a period of time in order to detect changes in relation to a baseline situation. **Evaluation** is the process of scrutinizing monitoring information in order to understand what difference a measure has made and what lessons can be learned. M&E should be integrated throughout the lifecycle of EbA measures, with the M&E framework designed together with the measures, and monitoring, evaluation and reporting carried out on a continuous basis.

2.1 Importance of M&E

There are a number of reasons why M&E is important for EbA:[19]

Understanding effectiveness

M&E helps us to understand whether or not an EbA measure is achieving its objectives. It also helps to show how and why EbA is achieving these objectives or not (e.g. what are the most effective or least effective components).

Adaptive management

M&E is needed to support adaptive management, i.e. adjusting the design and implementation of an intervention during implementation. This is especially important for EbA, given the need to deal with uncertainties (such as the evolving climate change impacts on people and ecosystems over time). M&E helps to track whether assumptions made at the start of EbA implementation were correct, and identify if changes are needed to make measures more effective and/or avoid risks of maladaptation.[20]

Information for policy and practice

M&E helps to strengthen the information or evidence for EbA, such as what measures are most effective in which contexts, and what kinds of impacts and benefits can be delivered. This information on the results of EbA can inform policy development, future practice and potentially the scaling up of effective measures.

[19] GIZ, UNEP-WCMC and FEBA (2020) Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn, Germany.

[20] According to the IPCC, maladaptation is 'an action that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future'. See IPCC (2014) Maladaptation is adaptation that results in unintended negative consequences, in GIZ, UNEP-WCMC and FEBA (2020) Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions.

Information sharing

M&E supports accountability and transparency, providing the information needed for reporting, review and sharing with stakeholders. These stakeholders can include beneficiaries, local communities, concerned government agencies, donors and taxpayers. M&E can provide information to demonstrate that resources are invested effectively and to show what have been the costs and benefits of EbA.

2.2 Suggested steps and practices for EbA M&E

Similar to the approach set out in the "Guidebook for the Design and Implementation of Ecosystem-based Adaptation in River Basins in Thailand", there are five key steps (Figure 4) for the development and implementation of M&E for EbA:

1) Developing **a results framework, such as a Theory of Change (ToC)**, to set out the desired impacts of the EbA measures and how these will be generated.
2) **Developing and refining indicators** for the EbA measures, covering the key aspects from the ToC and identifying methods to operationalize the indicators.
3) **Developing and implementing an M&E plan**, including training, equipment, data collection, review processes, etc.
4) **Communicating and sharing the information gained from M&E**, feeding knowledge gained form M&E back to local stakeholders and into policy processes.
5) **Carrying out adaptative management for the EbA measures**, ensuring that positive impacts are generated and negative impacts avoided/minimized.

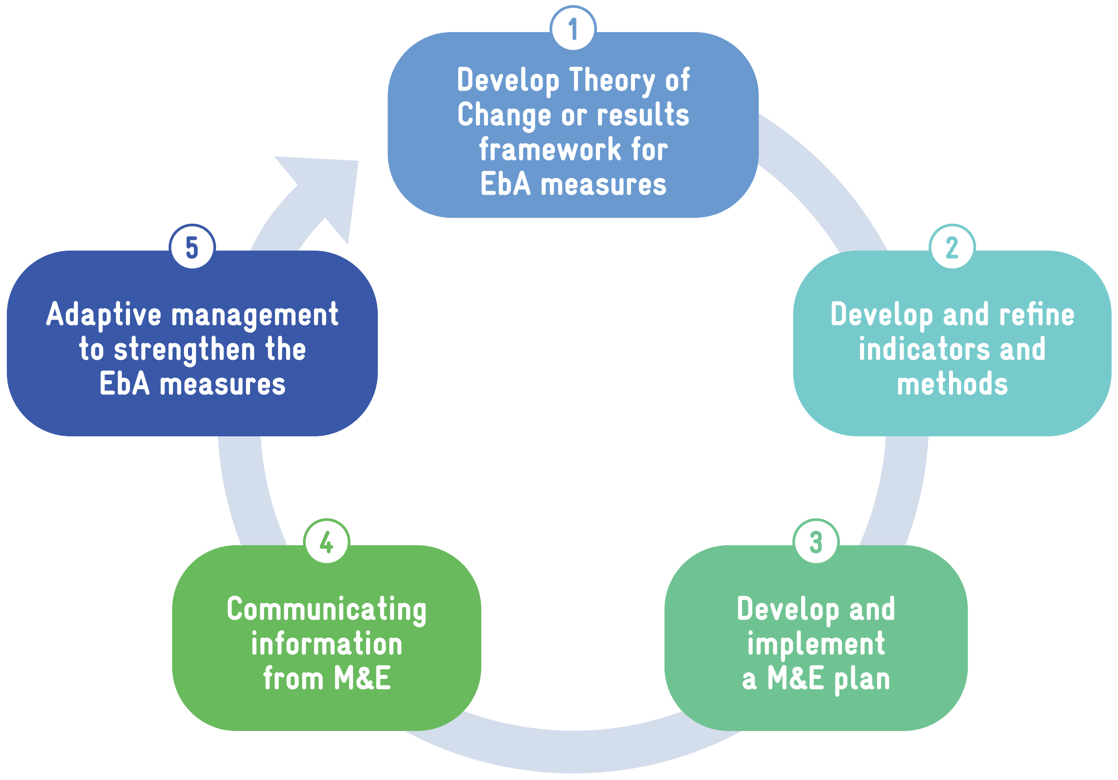


Figure 4: Cycle of five key steps for the development and implementation of M&E of EbA

Step 1: Developing a Theory of Change

The Theory of Change (ToC) approach is often used in the context of adaptation because it is particularly well suited to supporting the design, monitoring and evaluation of complex, multi-faceted and long-term interventions, like EbA. EbA involves complex socio-ecological systems and interactions. Changes in ecosystems happen over a long timeframe and therefore climate change adaptation outcomes take a long time to observe. A ToC uses a systematic approach to map out the anticipated causal pathway of change towards long-term objectives. It is useful to clearly define the intended purpose of an intervention by determining how and why change will happen. This helps to illustrate the cause-and-effect relationship between activities, outputs, outcomes and long-term impacts of interventions. The ToC also outlines the associated risks and assumptions in achieving the identified outcomes and impacts of interventions. This impact pathway can be a very useful tool in identifying the most suitable and appropriate indicators for monitoring an EbA measure or intervention.

A ToC is generally set out in the format of a flow diagram, linking EbA measures and activities to outputs, outcomes and the desired impact. Ideally the ToC would be formulated in the planning stage of an EbA measure but it is never too late to produce, as it can also be useful even for an existing measure. The ToC should be informed by the climate risks and vulnerabilities as well as the important ecosystem services in the area and the larger landscape. This guides the overall desired climate change adaptation impact, as well as the climate risks that the EbA measure should be addressing. Ideally stakeholders are also consulted in the development of the ToC and the design of EbA measures.

Steps to developing a Theory of Change:

1. **Identify the intended impact**: Define a statement that clearly and specifically describes the long-term goal of the measure, i.e. its impact. This can be ambitious but must contain sufficient details to be meaningful and tangible and clearly specify the climate hazards to which the measure is responding.

2. **Develop a pathway of change by systematically working backwards from the impact**: Start with the impact and design the pathway of change via a back-casting approach. This involves starting with the impact statement and for each step, asking 'what needs to be in place before this can happen?' Working backward in this fashion is advantageous in that it prevents a plan getting stuck by limitations in the present. See also Figure 5 below.

Figure 5: Simplified Theory of Change or results chain

Step 2: Developing and refining indicators and monitoring methods

Indicators are units of information (about particular objects, conditions, characteristics or behavior) that can represent (or act as markers of) the broader environmental, socio-economic or climatic situation. They can be both qualitative and quantitative.[12] Indicators underpin the practical applicability of an M&E system, providing a clear and straight forward way of identifying key aspects to monitor and structure an M&E framework. They help to determine whether an EbA measure is achieving its objectives and allow comparison between measures, regions/locations, and countries on adaptation achievements. **Indicators need to be identified on a case-by-case basis**, due to the wide range of possible EbA measures and contexts.

Based on the ToC, an **initial set of proposed indicators** can be developed to assess the most relevant points needed to monitor the implementation and effectiveness of the measures. In order to understand the effectiveness of EbA measures, emphasis should be on developing outcome and impact level indicators rather than only process indicators, though a combination of the two types, as well as contextual indicators (e.g. rainfall patterns in the area), is recommended. (See Figure 6 below on types of indicators and Table 1 for some example indicators from the water sector).

Indicators should be:

- **Specific and well defined**, so it is clear what is being measured
- **Valid**, meaning that they are based on a logical assumption about what is being measured
- **Practical and measurable**, so that is it is feasible to collect and process data and carry out analysis
- **Easy to interpret and explain**, so that different stakeholders can understand what is being measured and what the results mean
- At an **appropriate scale**, e.g. at the ecosystem or landscape scale, or another scale that supports assessing the effectiveness of EbA

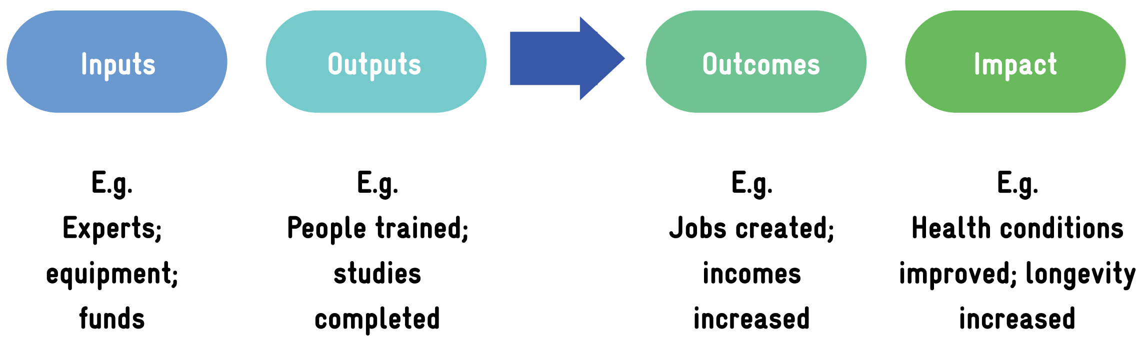


Figure 6: Indicator types[21]

[21] United Nations Development Programme (UNDP) (2002). RBM in UNDP: Selecting Indicators. Signposts in Development.

Table 1: Examples of water sector relevant indicators

Example indicator	Type of indicator (e.g. output, outcome)	Key topic/ category	Key topic/ category
Percentage of areas identified as important for groundwater recharge and erosion control that are covered by native vegetation	**Output**	Risk reduction; adaptive capacity	Vegetation cover may help with filtration and groundwater recharge, as well as controlling flow of sediments into waterways
Number of trainees (disaggregated by gender) participating in wetland/ riverbank restoration activities	**Output**	Community capacity building; community participation	Output/process indicator to show whether the training provided is reaching target groups
Abundance and diversity of fish species in the waterways	**Outcome**	Co-benefit (biodiversity); resilience to climate change (livelihoods)	The increase of fish populations and diversity is considered an indicate of ecosystem health, as well as a key priority for fishing livelihoods
Sediment load in rivers following heavy precipitation	**Outcome**	Risk reduction; adaptive capacity	The level of sediment may indicator whether measures such as restoration/sustainable land management are reducing run-off into rivers, and affects water quality
Trends in precipitation	**Contextual**	Contextual	Needed to understand rainfall conditions and trends in project area; relevant for analysing multiple indicators

Once a long-list of indicators has been developed, the next step is to **refine the indicator set**. Compiling indicators into a standard format, such as an indicator table, is a way to present metadata about the indicators, and to review and check their validity. For example, this provides a way to clearly present all the potential indicators for the M&E framework, so that any overlaps or duplication can be identified, and any impractical or illogical indicators eliminated. The technical and financial feasibility as well as the validity and any underlying assumptions should be checked and taken into account. The review process should include both stakeholders and local experts (with appropriate measures to ensure gender balance), and can refer to technical standards if relevant (e.g. water quality standards, IUCN NbS Standard, etc.).

The final indicator set also needs to have **clearly defined methods and data sources** identified. This should cover how data will be collected, processed and analyzed for each indicator, and the frequency of data collection. A baseline for each indicator may need to be established, against which change can be measured. For EbA it is important to include baseline information on climate variability and hazards. Some indicators may also need to have targets or thresholds defined, e.g. what counts as "good water quality". Targets are a way to assess a desired level of performance, or to evaluate whether an objective has been achieved.

Involving local stakeholders from the design and planning stage of M&E an have several important benefits for the long-term success of M&E, including co-identifying methods and monitoring points, increasing opportunities for long-term monitoring and data collection, and providing useful perspectives for the evaluation of EbA impacts (see Box 2 on participatory M&E).

Box 2: Participatory M&E

Where possible, participatory approaches should be integrated into M&E to support/corroborate the design and implementation of EbA measures. Participation can improve the basis for M&E through the contribution of local knowledge, contribute to efficient and long-term M&E, and increase transparency and ownership of EbA measures. Participation can improve the basis for M&E through the contribution of site-specific local knowledge, identify opportunities for communities to derive specific benefits from EbA, increase efficient and long-term participation in M&E, and increase transparency and ownership of EbA.

M&E processes can be designed to support a range of participation types, from more passive types of engagement, such as informing and consulting with local stakeholders, to more active participation in selecting indicators, setting targets, collecting data, and interpretation and decisions about changes to management practices (Figure 7).

If well-integrated among local institutions and stakeholder groups, participatory approaches can also help to make M&E viable over the long term, which is crucial for EbA measures, given the long-time frames associated with managing and restoring ecosystems. Training and capacity building should be included as part of the M&E approach, so that local stakeholders who are contributing to M&E have the skills and equipment needed.

Figure 7: Different potential levels of stakeholder participation[22]

Step 3: Developing an M&E plan and providing capacity building on M&E

In addition to defining indicators and monitoring methods, a plan should be prepared which sets out how the M&E is going to be carried out. This should include key aspects such as:

- The **overall objectives** of the M&E approach, i.e. for what reasons will the M&E be carried out.
- **Roles and responsibilities** for M&E, such as who will be coordinating, collecting data, analysing data, etc., including identifying relevant stakeholders to participate, such as community members and local authorities.
- Participatory approaches to M&E that will be applied, involving local rightsholders and stakeholders, authorities, civil society, and relevant government agencies across sectors, e.g. in the design of M&E through to data collection, communications of results, and decision-making on next steps.
- Any **capacity needs**, and what will be done to address those needs, such as training and other capacity building activities and equipment to be provided. This may include capacity building for the project team, but ideally will also cover capacity building for community members, local government or other stakeholders who will participate in M&E.
- **Timeline, key milestones and processes** for M&E, e.g. reporting processes, if mid-term and final reviews are needed, and procedures for adaptive management.
- **Consultations and information sharing processes** associated with M&E, e.g. appraisal workshops.

[22] Compiled from sources such as: Chambers, R. (2010) A Revolution Whose Time Has Come? The Win-Win of Quantitative Participatory Approaches and Methods. IDS Bulletin, 41(6), 45-55; Roy, H. E. et al. (2012) Understanding citizen science and environmental monitoring. Final Report on behalf of UK-EOF. NERC, Centre for Ecology & Hydrology and Natural History Museum.

- Any important **studies or surveys** that are needed as part of the M&E, such as baseline studies, biodiversity surveys, household surveys, etc.
- The **budget** available to support M&E.

Step 4: Communicating information and results from M&E

As noted above, the M&E plan should include opportunities for consultation and set out plans for how the results of M&E can be communicated and shared. This may include periodic evaluations, but should also consider consultation processes with local stakeholders to share results and gather feedback and take into account the most appropriate channels for communication, including the use of local languages. Consultation with stakeholders can provide insights into the effectiveness of EbA measures and help to assess progress on the indicators in the M&E framework. Recommendations for adaptive management or improvements to the EbA measures should also be discussed.

In addition to consulting with local communities and stakeholders, it is also important to plan for preparing results and sharing information at different levels, such as communicating the impacts and benefits of EbA with policy makers. M&E can provide crucial data on EbA measures to feed into relevant policy processes.

Step 5: Adaptive management to strengthen EbA measures

One of the main purposes of M&E for EbA is to provide information to support adaptive management (Figure 8). M&E can help to detect if something is not going as originally planned, understand why and adjust where needed so that the effectiveness of the measure can be improved or negative impacts minimized. Adaptive management is also about taking advantage of opportunities and building on the positive impacts of EbA measures. To carry out adaptive management, it is useful to make sure the M&E plan specifically includes processes for adaptive management, and that it is discussed in consultations associated with the M&E.

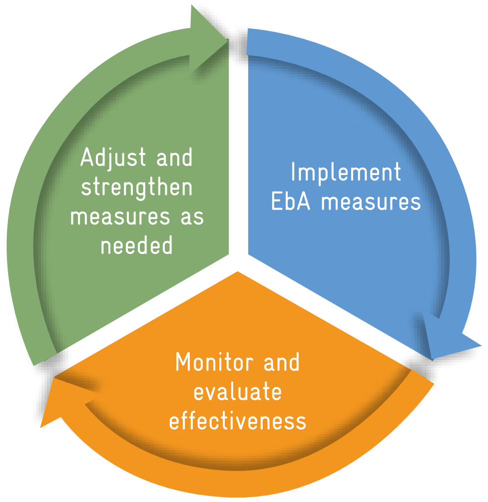


Figure 8: Adaptive management process for EbA measures[23]

[23] Guidebook for the Design and Implementation of Ecosystem-based Adaptation in River Basins in Thailand).

3

Piloting the Monitoring & Evaluation of EbA in Thailand's water sector

The purpose of the Joint Research Partnership (JRP) with five Thai universities was to develop and test methodologies for M&E of EbA, provide evidence on EbA effectiveness and inform future M&E efforts. More generally put, the JRP aimed to understand what works and what doesn't when developing M&E approaches for EbA and to gain insights and lessons learned to inform and eventually enable application in the Thailand water sector. M&E methodologies were developed for two different types of ecosystem-based flood and drought mitigation measures that are already in operation in Thailand:

- Natural and semi-natural flood retention areas in the lower Yom river basin, in northern Thailand, aimed at reducing the impacts of flooding in the basin in wet season; and
- Living weirs at two sites on the Khlong-La river, Songkhla province, and Khlong Wang Heep, Nakhon Si Thammarat province, primarily aimed at reducing the impacts of water shortages in the dry season.

In this section of the paper, information is adapted from the final reports of the university teams, unless otherwise specified.

3.1 Overview of the pilots

Living weirs

Living weirs are constructed from a bamboo grid across the river, and filled with sandbags containing natural materials, such as sand, coconut coir and manure. Along the riverbanks, different trees and plants are planted to stabilize soil. Banyan trees are planted either side of the weir and over time will grow to incorporate themselves to form the 'living weirs'. Living weirs are understood to have a number of benefits for reducing the impacts of flood and drought through for example improving ground water recharge as well as other co-benefits to biodiversity. They are also relatively

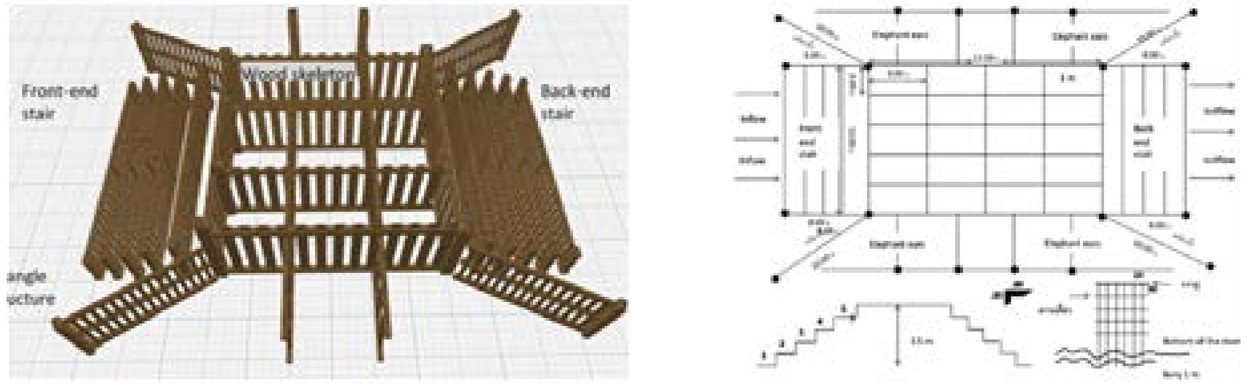


Figure 9: Structure of living weirs (provided by the Living Weirs M&E project)

Figure 10: Examples of living weirs in the pilot sites (provided by the Living Weirs M&E project)

cheap to maintain.

Living weirs construction has expanded in Thailand, mostly in response to severe drought conditions and to recover ecosystem services. In Khlong-La sub-district, Songkhla province, living weirs were introduced in Moo 3 village as part of a community research project by the Prince of Songkhla University in response to the 2014 severe drought. This project provided training to village members in living weirs construction and the first living weirs was built in 2015. A living weirs builder group was established and another severe drought in 2015-2016 prompted a series of nine living weirs to be constructed. In Khlong Wang Heep sub-district,

Nakhon Si Thammarat province, in Ban Pak Klong village (Moo 11), the living weirs concept was introduced by a "living weirs teacher group" in response to a need to restore the ecosystem and store water for use during the dry season. Through community action, the abbot of Wangkhri temple, local government, volunteers and the living weirs teacher group have built a living weirs in Moo 11 (see Site B information below).

Of the various living weirs described above, some have not been maintained while others maintain their functions to some extent. As yet, there is a lack of evidence to prove the effectiveness of living weirs in flood and drought mitigation and therefore M&E is needed to fill this information gap.

The living weirs included in this study are located at two pilot sites on the Khlong-La river, Songkhla province, and Khlong Wang Heep, Nakhon Si Thammarat province:

- Site A, located in the Khlong-La river, has four living weirs on the main channel and tributaries at 7 different villages. Located in Klong-la sub-district in Songkla province, the Khlong-la is one of the main rivers in the Khlong-Hai-Kong sub-basin. This basin has seen wide-scale development of water-related infrastructure and an increase in tree crops like rubber; the area often experiences severe drought conditions (e.g. a particularly severe drought event occurred between 2013-2015). These water shortages in the sub-basin are predicted to increase into the future with climate change.
- Site B consists of one small living weirs on the midstream of Khlong Wang Heep, Namaipai subdistrict, Thung Song district, in Nakhon Si Thammarat province. Aimed at reducing the impacts of water shortages experienced during 2013 – 2015 and in the future, this living weir was constructed along the midstream of Khlong Wang Heep canal during 2015-2016 by a group of villagers in order to retain more stream water in wet season, which can be used later for community water use. As in Songkhla province, further water shortages due to climate change are a concern.

A team comprising Prince of Songkla University and Walailak University led the development and testing of an EbA M&E framework for these living weirs sites.

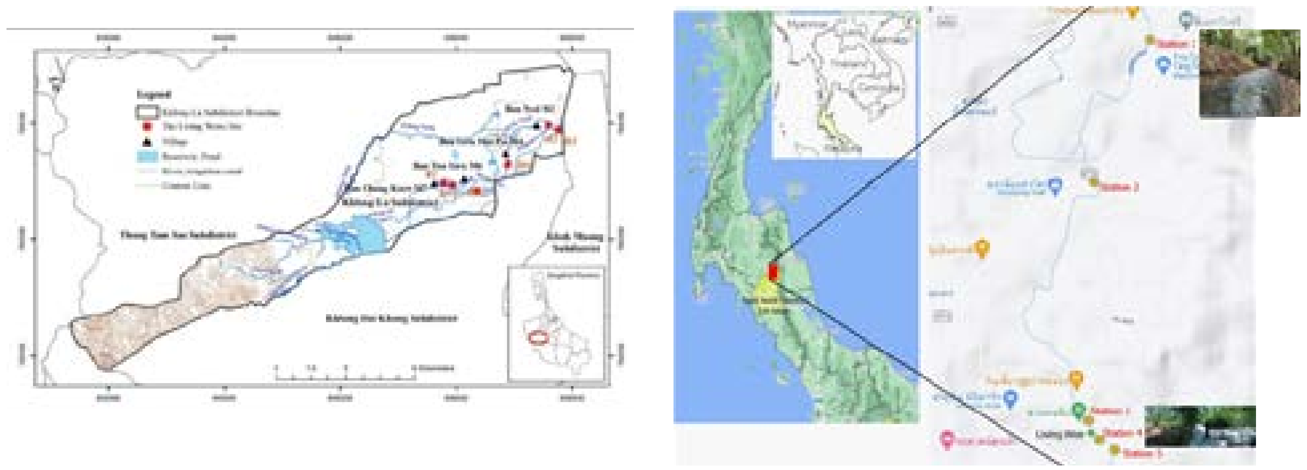


Figure 11: Maps of living weirs study sites (site A, left, and site B, right) (GEO-Informatics Research Center for Natural Resource and Environment, 2021) (provided by the Living Weirs M&E project)

Floodplains

The Yom river is one of the main rivers in the Chao Phraya river basin, in northern Thailand. Although it is considered to be less modified than other catchments in the basin, it has been affected by land use change and flood control and irrigation infrastructure, which have modified the river's usual seasonal patterns. The river rises in Payao province and runs southwards through Phae, Sukhothai, Phitsanulok, Pichit, and Nakon Sawan province. Much of the catchment comprises flat plains, and it was formerly forested with tropical deciduous or monsoon forest. However, most forest has been cleared for agriculture; rice fields are concentrated along the lower part of the basin.

Severe flooding in Thailand in 2011 prompted the development of the 20-Year Water Management Master Plan (2018-2037) by the government. This included measures to mitigate against flood risk, including flood retention areas to retain excess water. In the floodplain of the lower Yom river basin, many flood control measures have been developed, including the Bang Rakam Model, a major flood diversion scheme. This aims to control flooding by using low-lying areas as a buffer at times of flooding, establishing a cropping calendar to accelerate crop establishment and harvesting in target areas, abandoning traditional varieties of rice, and double cropping before and after floods. Since 2017, many flood detention systems have been implemented along Chao Phraya river and its tributaries. The idea is to create 'room for the river', with wetlands acting like a sponge to store excess water during wet periods and maintain water in dry periods. Natural and semi-natural wetlands are also expected to contribute to multiple benefits for the economy and environment.

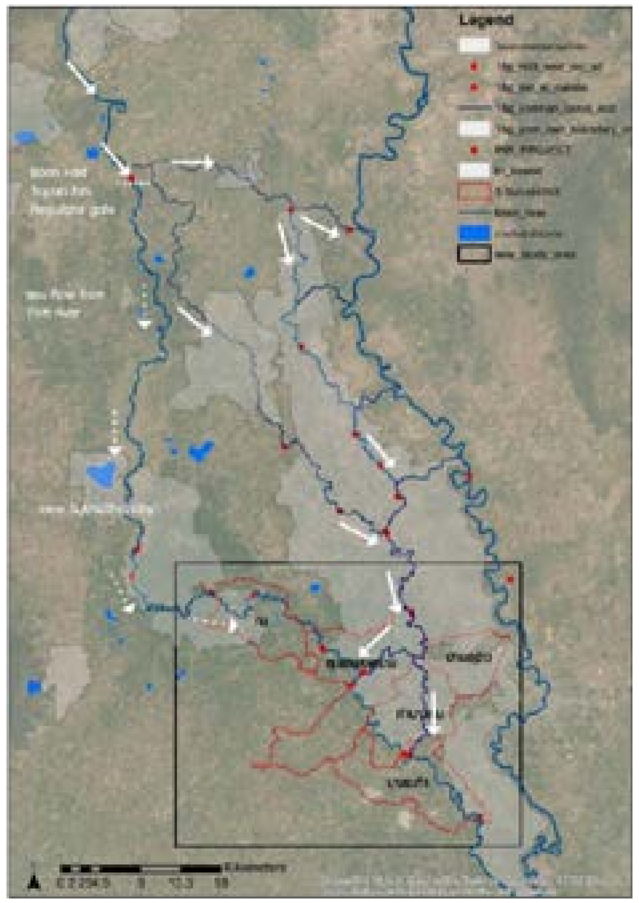


Figure 12: Current flood control system in the study area (provided by the Floodplain M&E project)

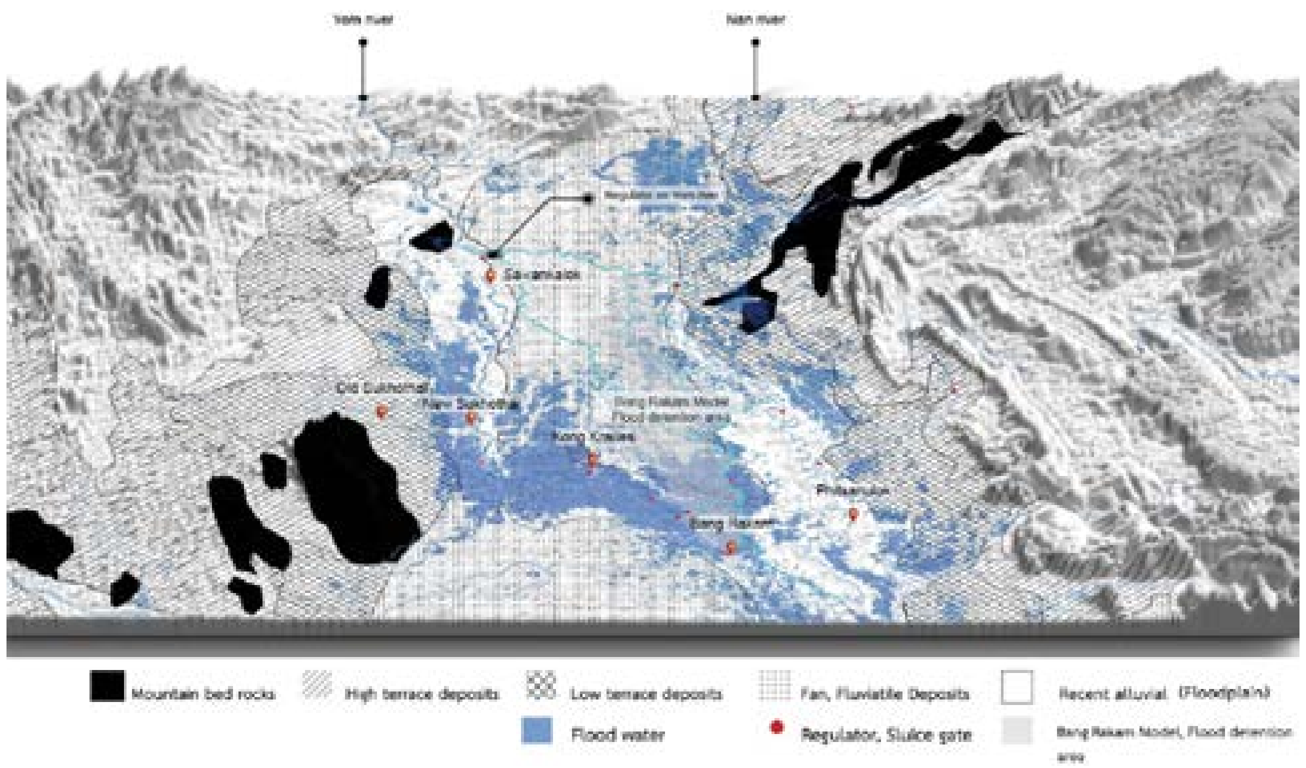


Figure 13: Flood diversion on the Yom River to Bang Rakam flood detention basin (adapted from Dheeradilok, 1987; Tongchai, 2021; GISTDA, n.d.) (provided by the Floodplain M&E project)

The study area for the floodplains pilot covers the lower Yom river basin, encompassing two types of floodplains: an unregulated floodplain in Kong sub-district (in Sukhothai province); and a regulated floodplain covering Tha Nang Ngam, Bang Rakam, Ban Krang and Chum Sang Song Kram sub-districts (in Phitsanulok province). Along with the floodplains and detention schemes, these areas are marked by intensive agriculture, particularly for rice, which has modified the landscape. Chulalongkorn University, Naresuan University and Mahidol University together developed and tested an M&E framework to evaluate the flood detention areas in the Yom river basin.

[24] Molle, F., Chompadist, C. and Bremard, T. (2021) Intensification of rice cultivation in the floodplain of the Chao Phraya Delta. Southeast Asian Studies, 10(1), 141-168.

3.2 Developing the M&E frameworks

With guidance from ONWR, GIZ Thailand and UNEP-WCMC, the five universities in the JRP have followed and adapted a step-by-step process for the development and application of M&E for EbA in the two pilot studies. This process has been based on the "Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions", and the five-step process described above (Section 2). However, as the EbA measures were already in place, some steps were adapted and tailored to the specific context for the pilot studies. In addition, the pilots aimed to test digital solutions and participatory approaches. Therefore, the university teams focused on the following steps:

Step 1. Developing a Theory of Change or results framework for the existing measures, focused on defining key outputs, outcomes and impact, to inform the development of the M&E approach;

Step 2. Defining and refining indicators, focused on assessing the hydrological, environmental and socio-economic impacts of the EbA measures, linked back to the ToC;

Step 3. Operationalizing the M&E approaches, by defining methods to assess the indicators and carrying out data collection and analysis, making use of digital solutions and participatory approaches where possible;

Step 4. Communicating results back to stakeholders in the pilot areas, and preparing reports and briefings for policy-makers.

Step 1: Developing a Theory of Change or results framework

A Theory of Change – as introduced in Section 2 - was developed for both the living weirs and floodplains as EbA measures, in order to show how the measures are intended to achieve the desired outcomes and impact in terms of adaptation to climate change and the reduction of risks from floods and droughts. The teams used a "backcasting" approach, but modified the ToC process because the EbA measures are already in place in the pilot areas. Starting from the overall desired impact of the measure, teams worked backwards in a step-wise approach to define results chains, i.e. the pathways between the EbA measures through to the outputs and expected outcomes, all leading towards the impact. The teams were also careful to define the desired impact in a specific way:

- Expected impact of living weirs: "Drought risk is reduced due to adopting community-based water management that can provide co-benefits for ecosystem services"
- Expected impact of floodplains: "Flood & drought risks to communities are reduced, and social and environmental co-benefits provided, improving communities' resilience to disasters and climate change"

The results chains were developed noting that implementation has already taken place, and therefore activities and outputs were already carried out. For example, in the case of the living weirs, this has included things like: living weirs have been constructed and maintained, with community involvement in their management.

After setting out the activities and outputs associated with the EbA measures, the teams then identified the expected outcomes, i.e. the results that the living weirs and floodplains could be expected to generate. These included immediate or short-term outcomes (such as more water being retained upstream of weirs, and increased community awareness about flood risks) and intermediate or longer-term outcomes (such as increased water availability in dry season, and reconnection between the river and floodplain habitats). The teams attempted to draw clear pathways between the EbA measures, the activities and outputs, on the expected outcomes, and finally the overall impact for reducing risks and increasing resilience. In addition, the teams paid attention to defining the types of outcomes included in the ToCs, such as whether the expected outcomes were related to hydrology, biodiversity, livelihoods, adaptive capacity of communities, etc, and whether there were important co-benefits, risks or costs, and assumptions that also needed to be monitored. An example of a risk associated with living weirs is that a lack of maintenance affects their functions; in the case of the floodplains, a possible environmental co-benefit included in the ToC is that improved agricultural practices could lead to reduced use of chemical fertilizers and pesticides.

An example ToC from the living weirs pilot is shown below (Figure 14).

The development of ToC for the EbA measures was a challenging process – partly because the EbA measures are already in place – but provided a valuable method for clarifying the critical areas that should be included in the M&E frameworks for the measures. As mentioned in Section 2, ToC development should involve a diverse set of stakeholders, as this helps to incorporate different perspectives and highlight a wider range of relevant impacts, risks and assumptions, which can help to reduce risks (such as loss of livelihoods) and enhance benefits (such as improved biodiversity conservation) from EbA measures. However, the two teams found that this process required a long time and the participatory process needs to be well designed and facilitated in order to get the most useful results and avoid confusion between stakeholders.

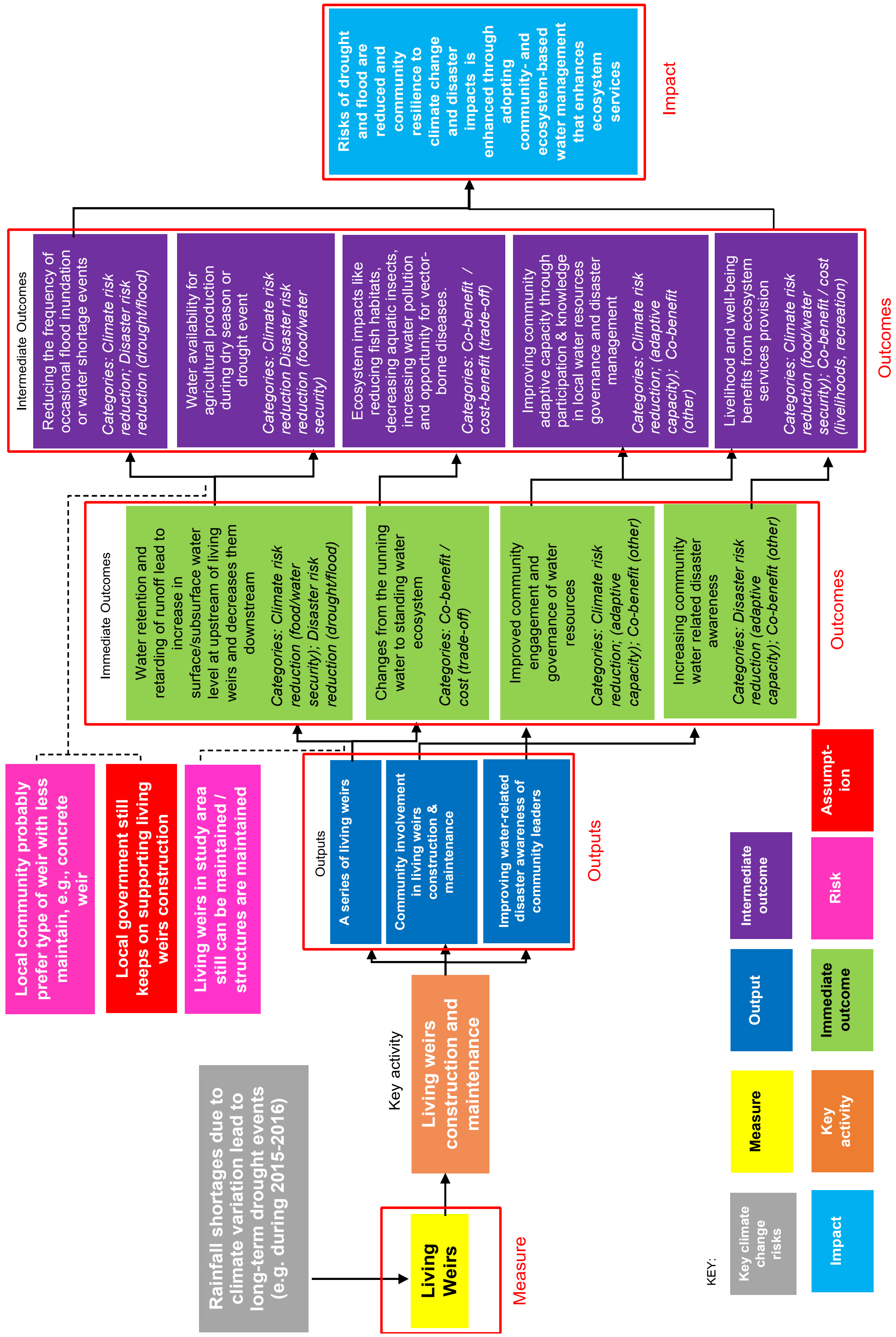


Figure 14: Example of Theory of Change for living weirs, adapted from the Living Weirs M&E pilot study (provided by the Living Weirs M&E project)

Step 2: Defining and refining indicators

Based on the ToC and the critical topics for monitoring that were identified, teams then developed a set of **indicators** that could be used to monitor the different stages and different types of expected outcomes along the climate change adaptation impact pathways for the two EbA measures. The approach used was to first develop a 'long list' of potentially relevant indicators, ensuring to include a combination of process-based and results-based indicators. These indicators were also categorized in a similar way to the key topics and outcomes in the ToC, e.g. indicators for assessing hydrological outcomes, environmental outcomes, and socio-economic outcomes, as well as contextual indicators (that provide information on the climate or demographic context, for instance) and indicators specifically looking at co-benefits, risks, or costs/trade-offs (e.g. potential negative impacts on local livelihoods.

The teams examined the long list of indicators to check that they were specific, measurable, feasible and relevant to the EbA measures and the expected outcomes. They then refined this long list to a more manageable and prioritized list of indicators, by reviewing the ToC and checking the validity of the indicators. To organize the indicators, the teams used an indicator table where they inputted and categorized their indicators – see example table in Annex 1. The resulting indicators aimed to monitor and evaluate the impact and benefits of measures across hydrological, environmental and ecological, social and economic aspects.

Annex 1 provides a few key examples of indicators that were developed for the pilot M&E frameworks; it is not possible in this r to provide the full indicator tables but these are available in the teams' full technical reports.

Step 3: Operationalizing M&E approaches

Once the indicators used to monitor and evaluate the EbA measures were selected, along with proposed methods and data sources, the two teams then **operationalized the M&E framework**. Since this was a piloting exercise, teams tested a variety of different methods to monitor hydrological, ecological and environmental, and socio-economic aspects in order to determine whether the EbA measures are effective in climate change adaptation. These methods were developed and applied at the pilot sites, with particular focus on participatory and digital-based approaches. Detailed methodologies for operationalizing each indicator are provided in the teams' technical reports, but the main approaches used are summarized below.

Hydrological indicators across the two EbA measures included but were not limited to: sub-surface water level; soil moisture content; river water level; surface water connectivity and flow; hydrological response; hydrological alterations; and flood and drought occurrence. Methods for monitoring these hydrological indicators included sampling and field measurements, but also digital technologies such as hydrological models and remote sensing. Notably, a data collection mobile application was piloted at the living weirs sites, through which data collected by the community are shared, helping to promote the long-term sustainability of M&E. Remote sensing, including images from satellites and drones, was used to monitor changes to land use and land cover, river morphology, flood occurrence and soil moisture in the study areas, providing another cost-effective method for M&E. The key hydrological models and other techniques applied to the data were:

- Living weirs: simulation models of stream water level and sub-surface water level upstream and downstream of living weirs in 2 scenarios (with/without living weirs, using for example MIKE-SHE, HEC-HMS and HEC-RAS); 2D electrical resistivity and soil moisture meters to measure soil moisture; and laser distance meter for measuring depth of sub-surface water level in shallow wells.
- Floodplains: integrated surface water modeling (SWAT) and groundwater modeling (Modflow) to assess surface water connectivity and flow; stable isotope analysis and GRACE (Gravity Recovery and Climate Experiment) and GRACE Follow-On to assess hydrological response (i.e. interactions between rainfall, surface water, and groundwater); using free processed satellite imagery from Gisagro 4.0 (Gistda.or.th) to estimate change in agricultural land and thus indicate hydrological alterations; using GIS based on satellite imagery time series to assess flood risk reduction efficiency; high resolution denudation capacity of drainage area, using drone and Real-time Kinematic Global Navigation Satellite System (RTK GNSS) for image acquisition, photogrammetric software (Pix4D) to process images, and digital surface models to visualize the change and scenarios over time.

Environmental and ecological impacts were mainly monitored through indicators on water quality, aquatic and terrestrial biodiversity and land cover change, including specific methods such as:

- Living weirs: Surveying and species diversity indices (Shannon and Simpson indices, and Biological Monitoring Working Party (BMWP) and Average Score Per Taxa (ASPT)) to assess species diversity of aquatic insects and aquatic prawns, crabs, snails and fish; using water sampler, portable meter, Multiprobe (HORIBAO) and test kit (e.g. pH, dissolved oxygen meter, total dissolved solids, spectrophotometer, temperature, nitrates, etc.); bat detectors (acoustic monitoring devices), mosquito traps and Mann-Whitney index to estimate bat species richness and prey abundance.
- Floodplains: Assessing surface water and groundwater quality (physical and chemical parameters based on raw water standards); using historical and recent maps to understand land use and land cover change (e.g. Figure 15 below), with implications for ecosystems,

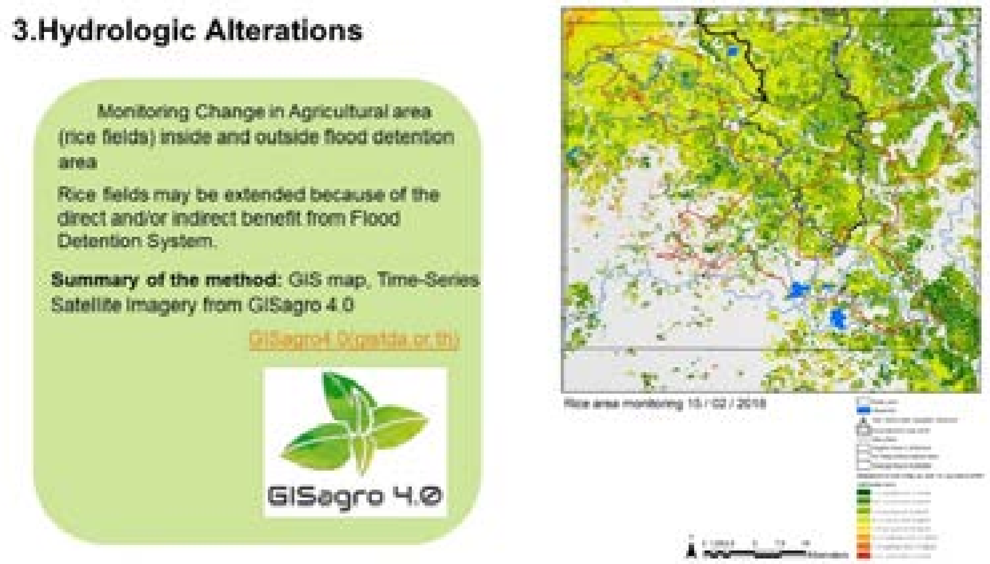


Figure 15: Rice fields inside and outside Bang Rakam Model (provided by the Floodplain M&E project)

Socio-economic factors, impacts on communities and governance aspects were also discussed and monitored through a mixture of household surveys, community interviews, public meetings and focus group discussions. The teams also applied methods to analyze costs and benefits of the EbA measures:

- Living weirs: Focus group discussions with community leaders, living weirs builder groups, and local government staff on the measures and their functions, as well as related aspects such as local water governance; a local geo-social map was drafted with community leaders on the study area and the potential target respondents; questionnaires were used to collect opinions on positive and negative impacts of the weirs from households, including via phone calls; using Likert rating scale to analyze level of benefits; secondary data and in-depth interviews, including a household questionnaire on willingness to contribute (WTC) and regression analysis (STATA program) to calculate benefit to cost ratio.
- Floodplains: Questionnaires to households covering uses of the flood detention area, economic conditions, household information, residential information, land holding and land use, living conditions, and the establishment of management organization; the results of which were analyzed in SPSS Statistics; outcomes of public meeting/forums on perspectives of the EbA measure and recommendations for the future.

Figure 16: Focus group discussions in living weirs (left) and floodplains (right) pilot sites (provided by the Living weirs M&E and Floodplain M&E project)

The **participation of stakeholders**, especially community leaders, community members and local authorities, was an important element of the pilots (Table 3). As noted in Section 2, participatory approaches can be highly valuable for M&E for EbA measures, and a range of different techniques, ranging from consultations, to surveys and focus groups, and active participation in data collection, can be used. During the pilot study, the two university teams trialed a number of these techniques, as shown in Table 3 below. The purpose of using participatory approaches in the pilots was twofold: 1) to test these approaches and their value in the M&E frameworks, and 2) to explore options for long-term engagement of communities and stakeholders in EbA more broadly.

Table 3. Participatory M&E approaches tested in pilot studies

Passive-active spectrum	Participatory approach	Living weir	Flood plains	Description
More passive	Identification of stakeholders	X	X	• Stakeholder mapping • GIS mapping to identify likely beneficiaries/stakeholders • Participatory mapping of study area
	Consultations with local communities & other stakeholders, and awareness raising	X	X	• Consultations with local stakeholders at early stage of pilots to inform people about the project, get feedback, COVID safety and understand more about the communities, their vulnerabilities & priorities, and the measures • Consultations in later stages to share results of studies, get feedback and discuss stakeholder perspectives on the measures and potential future actions • Showing/sharing information with local children/students interested in the project
	Discussions / interviews with community leaders, key informants and authorities	X		• Learning more about local context and priorities, and how EbA measures have been implemented (e.g. from living weirs builder groups) • Seeking guidance on monitoring topics, sampling locations and methods • Using local knowledge to design & refine questionnaires
	Household surveys and focus group discussions	X	X	• Collection of information from community members through household surveying and focus group discussion (e.g. farmers, fishers) to assess socio-economic, governance and related conditions and impacts of EbA measures

Passive-active spectrum	Participatory approach	Living weir	Flood plains	Description
	Community member involvement in administering surveys	X		• Training local community members & students and having them help administer questionnaires
	Community / local authority involvement in data collection and analysis	X		• Community members helping to install equipment, receiving training and collect hydrological data (e.g. level staff gauges, laser distance meters, soil sampling), and assisting with site and equipment maintenance • Development of a mobile phone application/line group and use of public spaces to report information like water level • Students and community members assisting in sampling of aquatic insects, catching fish for surveys, etc. • Community leaders also trained in data analysis (e.g. water level, volume, flow velocity, soil moisture) • Sharing data analysis by using simple statistics to local staff and authorities • Plans to equip relevant governmental organizations and/or community leaders for using drones and open-source software via practical video tutorial, to promote ongoing M&E

Passive-active spectrum	Participatory approach	Living weirs	Flood plains	Description
	Application of local/traditional knowledge & practice to support M&E	X		• Local community leaders designing a floating ball device for measuring water velocity with living weirs team
More active	Community involvement in further discussions and decision-making about the EbA measures	X	X	• Via consultations, community feedback and recommendations for future management of EbA measures and exchange on community-based water resource management • Evaluation of living weirs condition and training in living weirs operations & management for community members

Both teams identified advantages related to participatory approaches, and encountered challenges:

- In the case of participation in hydrological monitoring, advantages include that equipment like water gauges, level staffs, and laser distance meters (for shallow well readings), etc, can be low cost and relatively easy to use. However, this type of monitoring also needs frequent measurements over the long-term, which can pose challenges for ongoing community engagement.
- Biodiversity monitoring such as collecting and analyzing samples of aquatic insects, molluscs, fish, etc., engaged local community members and children, with the living weirs team noting: "Children are naturally curious, so being a natural-based learning process classroom where they can come to learn about the research process and observe the nature and characteristics of living things has an indirect benefit…". However, sometimes experts are needed to identify species, sort samples, and explain differences between them.

- Focus group discussions targeted community leaders and government staff, while household surveys/questionnaires targeted community members. Focus group discussions proved to be a valuable tool, as they can confirm insights obtained from other methods, and can yield richer data. Questionnaires also proved relatively simpler to administer, including by local staff. However, some challenges include moderating discussion to allow different voices to be heard, reluctance to discuss sensitive issues, different understanding/interpretation between researchers and respondents, and the need for cooperation from communities and local government agencies to properly design and refine questionnaires.
- The COVID-19 pandemic posed another significant obstacle for some parts of the pilot studies. The teams could not access study areas and infection control measures limited community engagement activities. In the case of the living weirs team, a switch to online/telephone training for interviewers and for household surveying data collection helped to address this challenge.
- Citizen science was encouraged in the living weirs pilot study by training community members to monitor water level using staff gauges and uploading data directly into a mobile application, which then linked to a webpage. This helps local residents to be more aware of the functions and impacts of the living weirs, and the results were interpreted by the team in a way to make them easier to understand, and then communicated via Line (a mobile phone app).
- A more general challenge related to participatory approaches is that different community members and stakeholders may gain benefits or experience costs/trade-offs from the EbA measures in different ways or to different extents. This can make it difficult to engage the whole community, and so it is important to apply different methods to capture different perspectives (e.g. separate focus group discussions for some stakeholders, encourage participation of local authorities to make discussions more official or "public", outreach to people living further away from measures as well as closing) by.
- It can sometimes also be difficult to clearly explain the goals of EbA M&E or the pilot studies in this case. Efforts should be made to share information and provide a clear understanding from the beginning of the project, and to involve local stakeholders in designing and operating M&E, making them feel like "part of the same team".
- As noted by the Floodplains team, participation is a continuous process. Frequent communication with stakeholders is advised, throughout the project. In relation to the second objective of participation in the pilots – to explore options for long-term engagement in EbA – public engagement has benefits like improving the quality of decision-making and offering alternatives to explore, reducing the risk of conflicts once implementation begins, raise awareness about likely results and impacts, provide channels for responding to stakeholder concerns, leverage community expertise and creativity, and contribute to strengthening social capital / adaptive capacity.

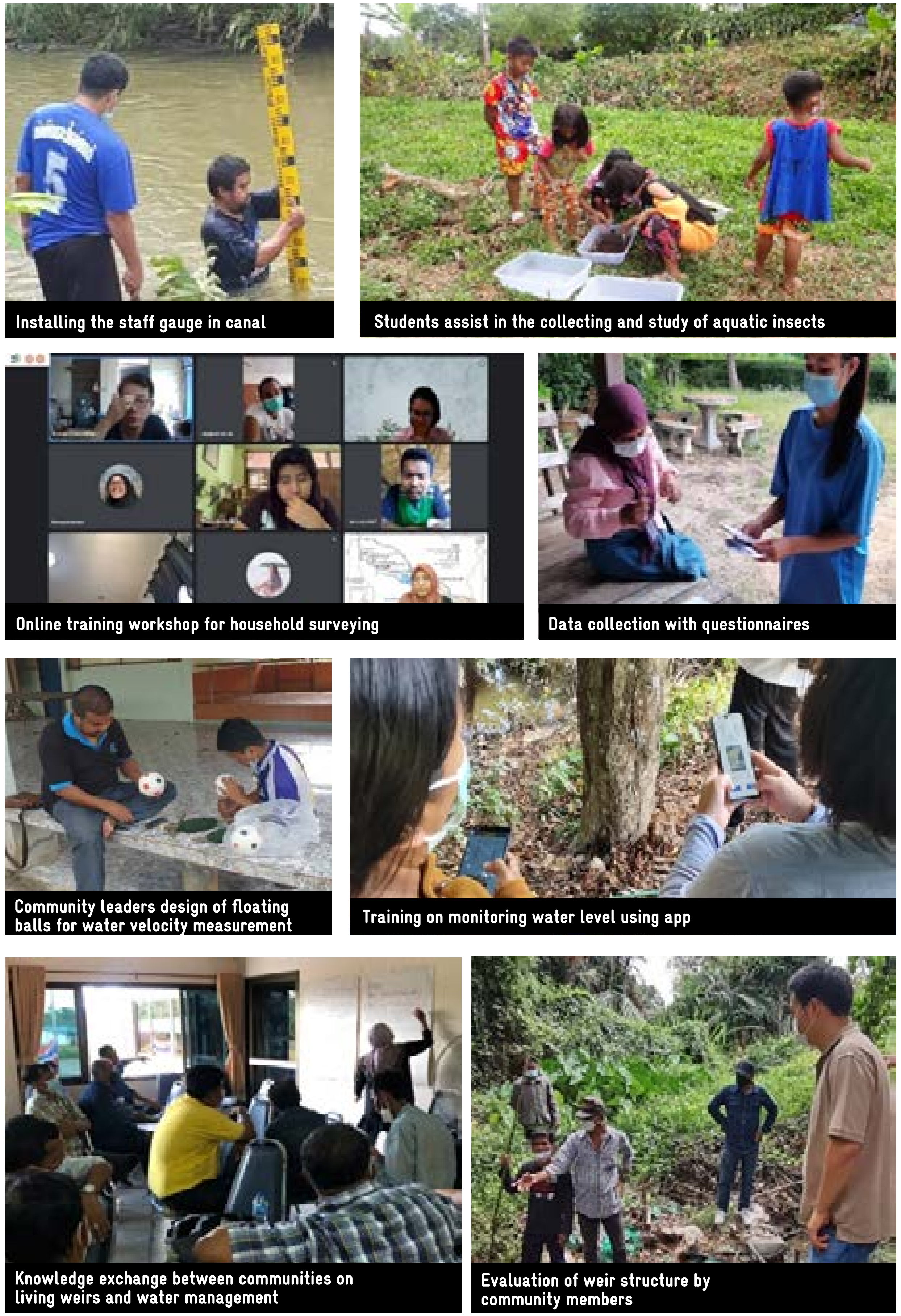


Figure 17: Photos of the participation of local stakeholders in the living weirs pilot sites (provided by the Living Weirs M&E project)

Figure 18: Focus group discussions in pilot sites (provided by the Living Weirs M&E and Floodplain M&E project)

Step 4: Communicating results to stakeholders

The final step carried out by the university teams is one that takes place on a continuous basis: communication with stakeholders. In addition to the participatory approaches described above, which including informing local communities and other stakeholders about the pilot studies and involving them in carrying out M&E, the teams also ensured that the results of the pilots were communicated back to local stakeholders, and to national-level policy makers. Results have been shared in the following ways:

- Feedback meetings held with stakeholders (including local community leaders and members, and the local authorities) to share the results of M&E, in terms of the impacts of the EbA measures, and to gain feedback on the long-term prospects for M&E and EbA measures themselves (see also Section 4.2 below on the stakeholder feedback received).
- Ongoing and regular dissemination of results also occurred; for example, the living weirs team used an automated telemetry station for monitoring stream water levels by automatically collecting, transferring, visualizing, and communicating data to local people via a Line group.
- Technical papers and presentations were prepared by both teams, setting out in detail the methods used and the findings of the studies; the teams also presented their findings back to the multi-sector JRP working group at national level.

4

Results of the pilot studies

Following the launch of the project in 2020, the bulk of the piloting of the EbA M&E frameworks took place in the two pilot sites during 2021-2022; the COVID-19 pandemic as well as flooding in the wet season posed some logistical challenges for the teams, which are further described below, along with some of the solutions applied.

Despite the challenges, the two pilot studies have generated valuable insights and lessons learned regarding EbA in Thailand's water sector, and more broadly. The results of the two studies fall into two main categories: 1) the impacts of the EbA measures themselves, i.e. the information collected against the indicators; and 2) the results or experiences of using the M&E approaches.

4.1 Impacts of the EbA measures

Although it can be difficult to summarize and compare the impacts of two different EbA measures, the pilot studies have shown that both EbA measures are delivering on the core goal of reducing vulnerability to hydrological climate change and disaster impacts. Both EbA measures are providing a set of co-benefits, for example by promoting community natural resource governance. However, the studies also show that the EbA measures involve trade-offs or costs; for example, related to livelihood impacts for some farmers and fishers.

The **intended outcomes** as a result of implementation of living weirs are as follows:

- **Outcome**: Living weirs reduce the risks of flood and drought occurrence (exposure) at the community level
- **Outcome**: Living weirs increase community resilience to climate change risks by increasing community engagement and raising awareness of climate change and disaster risks
- **Outcome**: Increased livelihood and well-being benefits from ecosystem services provided by the living weirs
- **Trade-off**: Potential modification of the ecological system due to changes in river flow regime and velocity

The intended outcomes as a result of implementation of the Bang Rakam floodplain model are as follows:

- **Outcome**: Reduce flooding in downstream urban areas like Sukhothai city. The diverted water will flow in the new canal and link back to Yom River again in Bang Rakam district.
- **Trade-off**: Unintended consequences to ecological structure and function due to diversion of water.

The main findings of the pilot studies related to the hydrological, environmental, and socio-economic impacts for both measures are summarized below. Table 2 below also provides an overview of the key findings of the pilot studies in relation to the main impacts of the EbA measures.

Table 2: Overview of the observed impacts of living weirs and flood detention areas

Hydrological impacts	Environmental impacts	Socio-economic impacts
LIVING WEIRS		
+ Water retention in upstream areas increased in both sites, potentially **helping to reduce water shortages** in dry periods	+ Positive impacts on habitat for aquatic insects fish, molluscs and decapods	+ **Participation** of some community members and **governance** related to living weirs / water management are strengthened
+ Some **slowing of water flow** in times of heavy rainfall at both sites	••• No impact observed on water quality	+ Numerous households gain **direct and indirect benefits** both upstream and downstream for domestic & agricultural water use and recreation
+ ••• **Sub-surface water level and soil moisture content** appears to slightly increase near living weirs in dry periods (site A). This increase is more pronounced upstream but more observation is needed	••• No impact observed for bat diversity (neutral) + and mosquito abundance (benefit for health & wellbeing)	+ **Cultural and leisure activities** around living weirs sites are increased though fishing remained the same
FLOODPLAINS		
+ Mitigation of **flood impacts** in the Yom river basin	– Some evidence of **decreased fish abundance** downstream of the flood detention area	+ **Income from fisheries and aquaculture** during flooded period within the detention area
+ Evidence that the flood detention area could **enhance groundwater recharge**	– **Reduced flood** in bypassed areas may lead to changes in physical and biological characteristics of riverine ecosystems	+ **Income from agriculture** in the dry season in flood detention area

Hydrological impacts	Environmental impacts	Socio-economic impacts
FLOODPLAINS		
- **Fragmentation** between river and floodplain disconnecting some areas from flood pulse	- **Fragmentation** of some areas of the floodplain may affect ecological processes that support ecosystem functions	- **Livelihoods of farmers and fishers** reliant on areas outside of the flood detention area negatively impacted
		- **Loss of rice cultivation** in the flood detention area during flooded period

4.1.1. Living weirs

Hydrological Impacts

Results indicate that living weirs **increase infiltration of water into soils, particularly in dry season and reduce runoff, depending on rainfall levels in wet season**, which contribute to mitigating the impacts of flooding and drought.

Soil moisture content was measured at a set of sample points upstream and downstream of the living weirs, but in-situ monitoring was unable to provide evidence of effects of the measures. Soil moisture content did not correlate with stream water levels, and variability in results may be due to pumping water for agriculture. Therefore, further investigation of soil properties and 2D electrical resistivity (rather than in-situ sampling) was used to show the influence of lateral flows from the weirs on soil moisture upstream and downstream of living weirs. This method indicated that there is a higher soil moisture content upstream of the living weirs. However, the higher soil moisture content was found in a very restricted area (at less than 15 meters from the riverbank) due to soil characteristics.

Results indicate that **sub-surface water storage has also increased slightly as a result of the living weirs**. This additional water storage has the potential to contribute to water provision in dry periods and maintain water supply within the community. In-situ measurements made in shallow wells in the proximity of the living weirs sites (both upstream and downstream) indicated that sub-surface water level followed a similar trend to that of stream water level. There was no significant upward or downward trend but some positive and negative fluctuations in shallow well water levels were observed throughout the monitoring period, which generally corresponded with stream water level. Some decreases in sub-surface water levels occurred that did not correspond to stream water level, which are thought to be due to water pumping for household use. Hydrological modelling simulating sub-surface water level showed that sub-surface water level varies with rainfall and the subsequent rise and fall of stream water. Simulated results also show that sub-surface water levels are slightly higher upstream of the living weirs in

comparison to downstream, indicating that living weirs can increase water level in shallow well by as much as 5 cm.

Results also suggest that **living weirs were able to slow streamflow**, demonstrated by the lower water level downstream of the living weirs in comparison to the upstream, including in heavy rainfall events. **This indicates that living weirs decrease flood risks in the downstream areas**, though this is not the case for all areas.

Environmental impacts

To assess selected environmental impacts, the team monitored water quality, as well as aquatic species diversity and bat activity (as indicators of biodiversity in the sites). Potential trade-offs were identified in the ToC, including the potential for ecosystems to shift from a flowing to standing water system, increased water pollution, and the opportunity for vector borne disease (estimated from mosquito abundance but not investigated in detail).

The living weirs have had **no discernable negative effects on aquatic and bat biodiversity, nor on freshwater quality**. In fact, the team put forward that the weirs may have a slight positive effect through habitat provision. They aid in slowing the water flow, allowing it to remain in the area for longer, and during hot/dry season aquatic animals may thus be able to survive better. In addition, mosquito abundance was shown to be similar at the living weirs and reference sites, suggesting that the weirs have not had a perceived negative effect by increasing mosquito numbers.

Socio-economic impacts

There was some evidence for **socio-economic benefits of living weirs, but these benefits are moderate** due to the relatively small scale of the living weirs in comparison to the size of communities receiving the benefits. These benefits include increased water availability for agriculture, especially in the dry season and drought events, and decrease in frequency that households are being affected by flooding. Estimates of construction and maintenance costs and benefits gained from living weirs indicated that the economic advantages of the weirs outweigh the costs (the cost-benefit ratio is 1.51 for base case scenario at Site A).

Living weirs building groups and local authorities financially supported the construction and maintenance of living weirs, with some financial contributions from the private sector. This has the potential to promote long-term local partnerships for community-based disaster-risk reduction and climate change adaptation.

According to the household survey, **cultural and leisure activities around living weirs sites increased** after construction (sample size=199) whilst fishing before and after living weirs construction remained similar. The majority of households use water from the canal or stream for domestic and agricultural use in the dry season (April to August, and 75% of the households across the two sites use canal water for agriculture. After the living weirs was constructed, the period of water retention showed a slight increase from 5 months to 5.3 months on average at Site A, though noting that this could represent the effects of different climatic conditions. Water use before and after living weirs construction remained similar, with households using water from the. the Klong La river canal, groundwater and irrigation water, and plant varieties grown did not change significantly after living weirs construction. However, results indicate that canal water was available for use for longer periods, which could indicate that living weirs increased water availability for communities.

According to the household survey, the number of households affected by flood 'every year' decreased after living weirs construction (32.8% to 26.5%), and the number of households reporting no flooding after living weirs construction increased (39.7% to 53.9%). Even though the wet seasons of some years in these periods (2015-2021) had extremely high rainfall, local people felt that flooding had decreased. The percentage of households that reported no drought periods increased after living weirs construction, from 70.4% before to 84.6% / 28 households after living weirs construction. Those reporting short drought duration (of a number of weeks) increased, but reports of medium drought periods (a number of months) decreased after living weirs construction. However, during the dry seasons of some of these years, rainfall was below average.

4.1.2 Floodplains

Hydrological Impacts

The Bang Rakam model has mitigated flood impacts in the Yom river basin by diverting water to the flood detention areas and transferring water to the Nan river basin. There is some evidence that the flood detention area could enhance ground water recharge from modeled results, though preliminary results from the GRACE analysis shows a decreasing trend in ground water storage and recharge in the study area. Satellite imagery to determine flood and drought risk reduction efficiency between 2017-2020 showed fragmentation between the river and the floodplain due to road and levee construction which has disconnected some floodplain areas from the flood pulse process.

Environmental impacts

The model has affected the Yom river ecosystem and livelihoods of farmers and fishers in Kong sub-district. Floodwater is essential for their livelihoods, but instead of flowing down to the natural floodplain, it is being diverted elsewhere. Anecdotal reports from fishermen indicate that there has been a decrease in fish abundance downstream of the diversion scheme. The flood control system uses barrage dams to divert water into the detention area which can have negative environmental impacts in themselves through reduced river flow, stage and velocity in the bypassed reach if the water diverts flows permanently into the bypass channel. There is also the potential for sediment aggregation in the bypassed reach if the bypass channel only takes flood water and not much sediment. Reduced flows in the mainstream can lead to change in physical and biological characteristics of riverine ecosystems.

Analysis of satellite imagery of flooded area in the study site show that flooded area is fragmented dues to levees, roads and flood diversion both inside and outside the Bang Rakam model which may be impacting ecological processes that support ecosystem functions and livelihoods.

Socio-economic impacts

The flood detention system in Yom River Basin effects two provinces, Phitsanulok and Sukhothai. Farmers face water insecurity, with water shortages in the dry season and flood impacts in rainy season. The government programme within the detention area promotes rice cultivation two times per year, meaning that government support is only available for two harvests (not the usual three). The flooding of the detention area during wet season means losses from being unable to engage in rice cultivation in the flood detention period, during which villagers use non–agricultural means for

livelihood including fishing and wage labour. Information on positive and negative socio-economic impacts emerging from the study are summarized below, as well as in Section 4.2 on stakeholder perspectives.

Positive impacts

The detention area is a source of income in both provinces. Agriculture in the detention area provides income and additional income is also gained from fisheries and aquaculture during flooding. Farmers supplement their income with fishing and other part time self-employment during the flooded periods. However, the period of flooding on the floodplain (in the retention area) is longer and more regular than prior to measure implementation and this could mean that income from rice has been lost. Though, it is not clear if income in the retention area is greater or less than before the Bang Rakam model was implemented. The majority of survey participants support the Bang Rakam Model, due to the perceived ability to 1) help to grow crops in the dry season, 2) help the people to earn more income, and 3) help to catch more fish.

However, these positive impacts are based on the last five years when the level of flood was maintained so the farmers could gain benefits from fish catch. Communities in both provinces also show some support for providing the land for flood detention. The socio-economic questionnaire found that the 64% of local people received compensation from the government during flood detention implementation and 34.7% did not receive the compensation. There is some willingness to participate in monitoring and evaluation activities (36.6% in Sukhothai province and 36.7% in Phitsanulok province).

In Sukhothai province, 51.4% of people agree that the ecosystem will be restored and improved and that, if the ecosystem is restored and maintained, that this will benefit the local level 50.7%. Moreover, people believed that EbA will be beneficial for the local economy and income 70.4% by disaster risk reduction 33.8%, increase local income 15.5%, and reduced cost of man-made system 14.1%. In Phitsanulok province, 42.4% agree that the ecosystem will be restored and improved and 11.8% mentioned that the restoration will have no effect. If the ecosystem is restored and maintained, the 50.7% believed that this will be beneficial at the local level. Moreover, 52% believed that EbA will be beneficial for the local economy and income through disaster risk reduction, increased local income, and land value or land use has increase 7.0%.

Negative impacts

However, diverting flood water away from parts of the natural floodplain is thought to have **negatively impacted the livelihoods of farmers and fishers** that rely on such areas that are outside of the diversion area. The unregulated area along Yom River such as Kong sub-district has experienced some unintended social and ecological consequences, due to diversion of water and prevention of the flood pulse, which is vital to maintain floodplain ecosystems and the livelihoods that depend on them, including fisheries and agriculture. Water that usually would flow downstream to the natural floodplain in the Kong district is instead flowing into the Bang Rakam model area. These impacts are exacerbated by land use change from flooded forest to intensive agricultural land and the associated infrastructure (roads and dike) that disconnect the river and floodplain.

Caveats

Although the results suggest that both measures are successful in contributing to climate change adaptation through reducing flood and drought, it is important to note that the monitoring period for all variables was short and mostly took place in 2021. Hydrologic modelling was used to simulate results, which is a useful tool to assess hydrological impacts over long timeframes involving complex processes but comes with a level of uncertainty. Further in-situ monitoring is still needed to validate results. For example, the impact of the living weirs on hydrology was also not easy to discern due to other variables impacting the data collected. For example, during the study period, ground water levels fluctuated as a result of pumping.

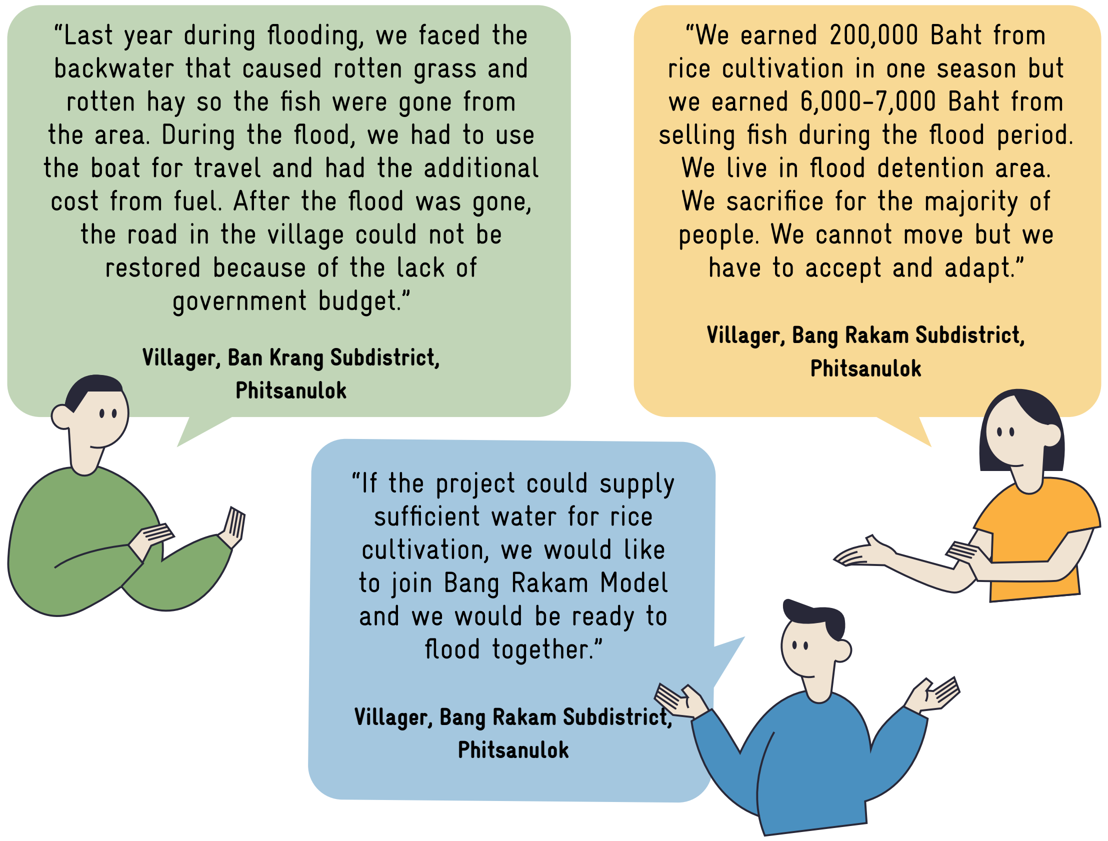
Environmental and ecological data were only collected over a relatively short period and it will be important to monitor this into the future. In addition, the monitoring was limited to several key aspects of the environment and ecology and may need to be expanded to ensure impacts are fully captured. Other topics of interest include pollution, especially plastic pollution potentially associated with living weirs materials (sandbags). Where negative socio-economic and environmental impacts have been identified as is the case with the Bang Rakam model, these should be effectively captured in monitoring efforts.

The socio-economic information suggests some moderate benefits are accruing from living weirs and both positive and negative impacts from the Bang Rakam model. However, without longer term climatic and other contextual data, it is hard to understand whether the reported impacts are caused by the measure implementation itself or by other factors. For example, respondents from the living weirs surveys reporting less flooding, noting high rainfall in the years examined in the study, could be the result of even longer-term changes in weather conditions between years.

4.2 Stakeholder perspectives on impacts of EbA

As mentioned in Section 3, the pilot studies included various opportunities to discuss the EbA measures with local community leaders and members, as well as the authorities, including through workshops, focus group meetings and household surveys. The results of these discussions are presented in Annex 2, showing the main benefits and trade-offs identified by stakeholders, as well as their feedback on M&E of EbA and the future of the EbA measures. It is important to note that the information below is a collation of the different stakeholder perspectives shared during the studies; different groups of people, especially those located in different areas in relation to the EbA measures, have experienced different impacts from the measures and have contrasting opinions on how to manage the measures going forward.

Some of the key positive impacts identified by stakeholders included: living weirs help to ensure the availability of water for household and agricultural use; and the floodplains can reduce flood risks and improve environmental conditions, such as soil quality. Negative impacts were also discussed, such as: the potential for water shortage risks downstream of living weirs; and the loss of livelihoods for people living in the floodplains water detention area. Stakeholders also put forward a range of suggestions for improving the EbA measures now and into the future, such as: strengthening the participation of community members in living weirs maintenance and water resource management; and measures to support local livelihoods, including compensation, for people affected by flooding in the Bang Rakam model.



4.3 Experiences from piloting the M&E approaches

In addition to providing important information about the impacts of EbA measures in the two pilot areas, the studies have generated valuable insights on how to apply certain M&E methods, when and where these methods may be most appropriate, and what challenges are involved.

These are summarized as follows, based on the lessons shared by both teams and JRP stakeholders:

Hydrological, environmental & socio-economic monitoring

- Hydrological data should be collected on a regular basis over the long-term to support community water management plans or sub-basin water management, i.e. beyond EbA M&E. Hydrological monitoring also needs to be carried out in a wide range of sites and areas, to compare results in different environments/contexts.
- Sub-surface water monitoring, e.g. using wells, poses some challenges, e.g. observations wells may be needed for this purpose, as existing wells may be affected by pumping, distance from the measures, surrounding land use, etc.
- Soil water content monitoring is similarly complicated, due to environmental factors such as soil type, land cover and land use, etc; sampling sites comparing upstream and downstream should be in similar environments to try and control for these factors.
- Installing new data collection equipment can be challenging, e.g. due to overgrown riverbanks and remote locations, and some equipment can be sensitive and difficult to calibrate.
- Environmental monitoring needs to consider the effects of other infrastructure and pressures in the area; for example, an upstream dam may have already had significant impacts on aquatic biodiversity, rather than target parameters like water quality.
- Expertise is needed for biodiversity sampling and analysis (e.g. field identification, sorting insects); if non-experienced people are working on this, training will be needed. Bats have been shown to be useful as one of the target species for biodiversity monitoring as the methodology is practical.
- It can be difficult to draw conclusions if using a limited number of sites and a limited number of samples; this applies to things like species monitoring, but also to socio-economic factors. It is also important to include people downstream and upstream of EbA measures to understand and assess any differences in impacts.
- Evaluating EbA costs and benefits is important in understanding whether or not it is a good investment. however, it can be hard to precisely evaluate these based on community inputs. Carefully designed questionnaires are needed, and expert advice should guide the evaluation.
- Future studies should explore a wider range of consequences for the environment, for instance pollution and microplastics may affect water quality and aquatic wildlife.

Digital approaches

- Relying on in-person data collection and field researchers proved difficult during the COVID-19 pandemic; alternatives such as mobile application offer a solution, but risks include poor mobile signal in some areas. COVID-19 also affected things like operation of labs for analysis of data.
- A multi-sensor approach (using GIS, modelling, and other sensors) can generate useful information and be used for creating scenarios, which can enhance community understanding.
- Developing applications for collecting data is a useful approach, though consistent use and ensuring long-term data collection and sharing is a challenge.
- The floodplains study using drones/UAV to collect imagery, along with processing using GIS methods, shows that this can be an effective way of evaluating flood impacts and flood risk quickly and at low cost. At the time of the study, a multi-copter UAV costing only 50,000 Baht and open-source software for processing can produce high-resolution images that show land use, flooded areas and other important factors. This can allow agencies to monitor the flood risk as well using a digital surface model (DEM), which can indicate areas prone to flooding. However, the area that can be covered is substantially smaller than satellite imagery, which can lead to biased data analysis. It also requires skilled operation for both collection and processing/analysis of data.

Participatory approaches

- Participation of community members in M&E had an added benefit of helping both the community and the academic team to more comprehensively understand the benefits/services obtained from the measures.
- Participation by community members and other stakeholders may depend a lot on their livelihoods and lifestyles; for example, less participation was achieved in areas dominated by farming. Participation methods need to be tailored to the community type and participants.
- There are both advantages and limitations to involving local people in data collection; it helps to overcome problems like access during COVID-19, but training was difficult to do properly online and with limited time.
- Residents may wish to participate more in practical activities (like construction), or at certain stages, rather than in ongoing discussions related to EbA. more effort is needed to ensure joint decision-making among stakeholders.
- The studies identified a set of benefits that were often common across different stakeholders and information sources, but trade-offs were not always discussed or clearly identified. Stakeholders should be involved at an early stage to set the scope and topics to cover, to help ensure a comprehensive set of benefits and trade-offs are considered.

5

Discussion: Lessons for Thailand's water sector

The pilot studies summarized in this report had two main goals: to assess the impacts of two EbA measures aimed at improving the resilience of communities to flood and drought in Thailand; and to test M&E approaches, particularly digital and participatory methods, to generate lessons for the Thailand water sector on M&E for EbA. The information and experiences gained through the two studies are of particular value for the future development of both the design of M&E frameworks for EbA measures, and the uptake and strengthening of EbA in the water sector. Lessons and recommendations on both these aspects are summarized below.

5.1 Lessons on M&E of EbA

Developing M&E frameworks:

- **M&E frameworks for EbA should be developed through robust approaches with stakeholder and expert involvement**. Ideally a ToC approach is used for the design of EbA measures, ensuring that a logical pathway is developed, from the implementation of the measure, through to the expected outputs, outcomes and desired impact. However, even for existing measures, where ToC were not prepared in the past, this approach provides a useful way to identify the critical points or topics for M&E.
- **M&E frameworks for EbA measures need to be comprehensive but manageable, and local perspectives can help achieve this**. This means that important elements – including hydrological, environmental, and socio-economic benefits, as well as costs and trade-offs of EbA – need to be included, as well as impacts on biodiversity, governance, food production, and other key factors. At the same time, M&E frameworks should be able to integrate important concerns and benefits identified by local stakeholders, taking into account gendered differences, which may only become prominent as their views and perspectives are communicated. For example, this could include impacts on economically valuable species, on health and wellbeing, and on specific groups of people, such as women, youth, the elderly, migrants, etc.
- **Specific attention is needed to develop gender-responsive M&E frameworks**. This means more than gender disaggregation of data (such as collecting data on income of men and women). It also means ensuring that indicators examine the different vulnerabilities of people of all genders, and that the different benefits and costs experienced by gender groups are captured. It also means promoting inclusiveness in participatory approaches (see below).
- **Contextual information for M&E is essential and needs to be included in M&E frameworks from an early stage**. The climate change and disaster risk context for the EbA measures, communities

and ecosystems involved, as well as demographic, land use change and other contextual information are needed to design appropriate EbA measures and for robust M&E. In particular this contextual data supports the analysis of other indicators and information, such as whether the EbA measures perform well as precipitation or temperature changes, in extreme events, or during economic shocks. Without contextual information, it will be difficult to draw conclusions about the impacts of EbA measures in the context of climate change.
- **Future M&E may benefit from exploring comparisons or scenarios related to EbA measures**. Although not feasible during the pilot studies for this project, valuable insights can be gained from examining comparisons or scenarios between the impacts of EbA compared to business-as-usual or no EbA, or with other types of interventions (e.g. traditional concrete measures). This can highlight the value or benefits of EbA compared to these other situation, but it can also demonstrate where EbA measures could be usefully combined with other types of measures to deliver greater impacts or benefits.

Conducting M&E:

- **Data collection and analysis can be resource- and time-intensive, but there are ways to minimize these challenges**. The pilot studies have demonstrated some of these options, such as collaboration with universities, students and local communities to assist in data collection. In addition, automated systems for hydrological monitoring, cooperation with university research projects, and the utilization of regular, institutionalized monitoring processes (such as agricultural censuses) can also help to increase the feasibility of M&E.
- **In Thailand's water sector, it is important to tailor M&E approaches so that they sufficiently examine impacts in both wet season and dry seasons**. This has implications not only for data collection across multiple seasons, but also formulating hypotheses and considering different types of costs and benefits that could be generated in different seasons.
- **Digital technologies offer relatively low-cost methods to support M&E, but also challenges**. Approaches like remote sensing using satellite imagery and drones for aerial photography, GIS mapping, and hydrological modelling are increasingly cost-effective in terms of equipment and coverage for a low investment (in terms of cash and human resources). However, expertise is needed to operate certain equipment, to process and analyse images, and to run hydrological models. Long-term, accurate data are also needed for better modelling results.
- **Online applications supporting community participation and citizen science** are also attractive, and can enable data collection, but quality control and ensuring the long-term participation of volunteers is an ongoing challenge. Incentives – including the usefulness of the data to the users – should be built into the development of these applications and platforms.
- **Participatory approaches for M&E are valuable for a number of reasons, but need to be recognized as more than a means to an end**. As discussed, participation of local stakeholders can assist in the design of M&E frameworks, the collection and analysis of data, and the evaluation of impacts. Information from local residents and the authorities also forms an essential data point, such as on the socio-economic impacts of EbA measures. However, the opportunity to participate in all aspects of the design and implementation of EbA measures, including M&E, is a basic right that should be offered to communities and other stakeholders, along with access to information about the measures.

- **A range of participation types should be included in M&E approaches, to help achieve different goals**. Participation in M&E of EbA can range from the more passive (such as receiving information) to the very active (such as collecting data and leading community action research). Each type of participation is a valid method, as long as it is appropriate to the context and the goals to be achieved, such as ensuring community members are informed about M&E and EbA, allowing local knowledge and expertise to improve M&E processes, or developing more sustainable/long-term M&E programs. As with digital technologies, participatory approaches also face challenges, such as ensuring access to experts when needed, providing training and equipment, and maintaining engagement rates. The pilots also show that certain M&E activities can be a valuable way to raise awareness and provide access to information about EbA, disaster risk, natural resource management, biodiversity and other topics.
- **Where possible, M&E for EbA should link to, make use of and integrate with other relevant data and monitoring systems**. This offers advantages in terms of accessing supplementary data, as well as building links with wider adaptation and IWRM programs. This may also depend on the availability of complementary data and monitoring systems in the local area or at national scale, but some examples include: wider M&E for river basin management; national monitoring and reporting on adaptation (e.g. for NAP or NDC); and local level monitoring of socio-economic development indicators.

Using & communicating results:

- **The information collected through M&E can have and should have multiple uses**. It can be valuable for local authorities for planning water management and EbA measures, but also for communities monitoring of water levels and other factors important to their livelihoods. Linking M&E to a range of uses and users – including government, communities, private sector, and uses beyond EbA alone - may generate a longer term commitment to M&E.
- **Communicating and discussing the results of M&E can provide a forum or platform for sharing concerns and strengthening EbA measures**. The workshops and stakeholder engagement processes during the pilot studies allowed information about EbA and the results of the studies to be shared back to the communities and local authorities, and prompted suggestions for the future, covering management of the EbA measures to broader development issues. Discussing the results of M&E can provide information for adaptive management of EbA measures, as well as a platform for different stakeholders to highlight different experiences and impacts from EbA and negotiate solutions moving forward. However, this process extends beyond M&E; the improvement of EbA measures and addressing stakeholder concerns also requires commitment to EbA over the long-term, funding and ongoing support.
- **M&E strengthens the evidence base for EbA, but the case for EbA measures requires information on the full range of benefits and costs**. The type of information generated in the pilot studies, and by ongoing M&E, is an important input to decision-making processes at local and national scales. It can improve the evidence on which EbA measures are performing well in which contexts, and what challenges may need to be addressed. However, to better support future decision-making about EbA, assessments, feasibility studies and M&E will ideally provide a full picture of the range of costs and benefits of EbA, including those benefits that

are difficult to value, such as biodiversity conservation, recreation, and community governance. Full transparency is also needed with regards to trade-offs, such as those experienced in the Bang Rakam floodplains model, so that they can be avoided or addressed. In addition, comparisons of the benefits and costs generated by EbA measures, compared to more traditional "grey" measures, or combinations of the two, will also provide valuable information for deciding which options will work best for communities, the economy and ecosystems.

5.2 Strengthening EbA measures and promoting scaling up

Recommendations for improving the two EbA measures

In addition to the stakeholder feedback shown in Section 4.2, the two pilot studies resulted in a set of recommendations for improving the operation of the two EbA measures studied, the living weirs in Songkla and Nakhon Sri Thammarat provinces, and the Bang Rakam floodplains model in Phitsanalok and Sukothai provinces. These are summarized below.

Living weirs	Floodplains
• Constructing cascades of living weirs may deliver more benefits from hydrological ecosystem services, compared to single weirs. • Only a small number of villagers know about/participate in living weirs activities, and more have participated in construction or repairs than in discussions. In the future, more efforts are needed to promote joint decision-making by stakeholders. Knowledge and participation by the community is needed for the long-term sustainability of the living weirs. • Management can be improved and made more systematic by the establishment of local living weirs and/or water management committees. • Cooperation between community and other stakeholders can also be promoted with formal (e.g. MOU) and informal approaches for water resource management. • Information about weir management must be communicated to the community on a regular and comprehensive basis, to enhance the transparency of the weir management model.	• Ensure that ecosystem and livelihood impacts are fully considered by implementing agencies – both inside and outside of the diversion area. • Prioritize urgent local concerns and solutions, such as water management in the flood detention area and livelihood development for affected people. • Future studies and/or monitoring should include improved ecosystem monitoring, such as on the condition of the natural floodplain. • Seek opportunities for restoration and management of natural floodplains, as a flood risk reduction measure that is likely to have fewer unintended/negative consequences on people and ecosystems. • Maintain the water level in canal/stream for fish habitat in dry season. • Select local fish species for release, that meet the ecosystem and local market needs, conserve areas for fish nurseries, and regulate the catch of small fish.

Living weirs	Floodplains
• More benefits from the living weirs could be generated through actions such as improving the landscape to attract tourists/visitors. • Reduce/avoid using synthetic sacks that have short lifecycle and use environmentally friendly materials for living weirs construction.	• Promote short-term rice cultivation in flood detention area with market channels for rice products. • Develop/promote rice varieties that are resistant to flooding. • Promote the establishment of farmer groups to empower the local people.

Recommendations for scaling up EbA

• **Prioritize areas for EbA measures that deliver multiple benefits**. EbA opportunity mapping can be used to identify priority geographical areas for the implementation of EbA, as well as options for how EbA could be located and designed to promote multiple benefits (e.g. increasing resilience, improving resource management, storing carbon, conserving biodiversity, etc). EbA opportunity mapping thus combines spatial information on the distribution of risks (like flood and drought risk), ecosystem service provision, and other factors (such as location of communities, protected areas, infrastructure, agriculture, etc), and can take place at multiple scales, i.e. for small scale, locally led interventions like living weirs, and larger-scale, landscape wide and publicly led programs like floodplain restoration and management. An example of this is South Africa's "Ecosystem-based Adaptation Action Plan and Priority Mapping", which includes identification of pilot locations and a five-year pilot program for EbA implementation.[25]

• **Promote participation, including with dedicated support and capacity development**. As shown by the JRP, local participation in EbA measures and associated activities can increase support for EbA, improve awareness of integrated water management (IWRM) and disaster risk reduction, and strengthen the long-term effectiveness of EbA. Gender balance should be sought to ensure that women and men benefit equally from training on M&E methods. Mechanisms and platforms are needed to allow for the increased participation of local communities, other government agencies and relevant stakeholders in planning, designing, implementing, and monitoring EbA. This does not mean new platforms always need to be established, and there is the opportunity to make use of existing mechanisms, like Thailand's river basin communities (RBCs), wetlands management groups, community forestry groups, etc. In addition to establishing or mandating institutions like RBCs to consider and promote EbA, there also needs to be dedicated support and capacity building on EbA and IWRM. Other options that can help to empower local action on EbA include public budgeting exercises with community participation in determining local budget allocations, small grants programs for EbA projects led by local government or community groups, and local-level payments for ecosystem services (PES) schemes and voluntary carbon market projects.[26]

[25] Department of Environment, Forestry and Fisheries (DEFF) (2019) Ecosystem based adaptation Action Plan and Priority Areas Mapping report. Pretoria, South Africa. Available from https://www.sanbi.org/wp-content/uploads/2020/10/Action-Plan-Priority-Maps-Full-Report-Digital-High-res.pdf

[26] United Nations Environment Programme (2022) Nature-based Solutions: Opportunities and Challenges for Scaling Up. Nairobi.

• **Integrate local knowledge and expertise**. The two studies in this report also make a strong case for the inclusion of local knowledge, expertise and creativity in the design, implementation and monitoring of EbA. This includes involving local communities and other stakeholders in the early phases of identifying key local and community challenges and needs, designing solutions for those challenges – which can include EbA measures – and helping to design EbA measures in a way that increases positive impacts and reduces negative impacts (like the loss of livelihoods). In the case of Thailand, local consultations may also help in identifying solutions in place of, or complementary to, financial compensation, which is still a standard approach to managing flood and drought impacts. Local knowledge and expertise have also proven valuable in the design and implementation of M&E, strengthening the development of indicators, helping to select monitoring locations, and support data collection, analysis and evaluation. Participatory processes should be designed to ensure that women and other marginalized groups are able to effectively share their specific needs, vulnerabilities and perspectives.

• **Ensure that EbA is generating benefits and managing trade-offs**. The design and implementation of EbA should focus on the generation of different types of benefits at multiple levels, i.e. starting with households and communities, and including districts, provinces, and the country as a whole. Interventions that do not deliver sufficient benefits and that do not recognize and attempt to manage costs or trade-offs are unlikely to be sustainable over long-term or to achieve their core objective: resilience for people and ecosystems. The pilot studies show that consultations with local communities and other stakeholders form a vital input understanding the scope and scale of potential benefits and costs from EbA, as well as options for enhancing benefits and reducing costs.

• **Consider the full range of EbA costs and benefits**. In addition to consultation, various tools and approaches are available to help generate and integrate information on the full range of potential costs and benefits of EbA in decision-making and planning. These include participatory assessment of benefits and risks, ecosystem valuation (e.g. guidance from The Economics of Ecosystem and Biodiversity, TEEB), and natural capital and water accounting (e.g. the UN System of Environmental Economic Accounting – Ecosystem Accounting, SEEA-EA). Natural capital accounting is being developed and tested in Thailand, focused initially on coastal and marine ecosystems. Accounting approaches offer a way to better identify and quantify the value of ecosystems and their services for multiple objectives, including adaptation, as it can indicate the full range of benefits offered by ecosystem services and potential costs associated with their degradation and loss. For example, SEEA pilots have taken place in Indonesia, Kenya, Malaysia, and Uganda focused on energy, air emissions and water accounts.

• **Apply best practices through technical standards and safeguards for EbA**. Like any intervention, EbA can have far-reaching impacts on ecosystems and communities, both positive and negative. Using technical standards and safeguards to guide EbA design, implementation and evaluation can help to ensure that measures are effective, respect the rights of local communities, protect biodiversity and the environment, and are more likely to deliver benefits. There are now a wide range of resources available to promote best practices and safeguards for EbA, including the 'Guidebook for the Design and Implementation of Ecosystem-based Adaptation in River Basins in Thailand, the EbA Code of Practice Compendium, and the toolbox on EbA for the Thai water sector developed by ONWR and GIZ under the TGCP-Water project.

Annex 1:
Some example indicators for the two pilot sites

ID	Indicator	Indicator type	Indicator focal area / category	Is this indicator a composite indicator?	If yes, list the IDs of all associated indicators	Summary description of the assumption or any thresholds for indicator	Summary of method/s to be used	Proposed data source/s	Proposed data source/s description
	Tip: Frame the indicator neutrally, so as not to anticipates the outcome	E.g. process / output / outcome / contextual	E.g. climate risk reduction, adaptive capacity, co-benefit, risk, contextual, etc	I.e. an indicator based on combination of parameters, like an index		I.e. how to assess the indicator / understand the trend. For e.g. for flood detention capacity, what is a good result? What is the threshold of regular flooding vs a disaster?	**Brief description** of data collection and analysis methods, such as modelling, comparison of GIS maps, household surveying, etc		
FLOODPLAINS – EXAMPLE INDICATORS									
1	**Changes in water quality**	Outcome (intermediate)	Climate risk reduction (ecosystem service delivery)	Yes – multiple parameters	n/a – not tied to other indicators	Surface water quality is expected to improve with improved ecosystem functions.	Physical and chemical parameters based on raw water standards	Primary data collection	Analysis by team
2	**Flood/ drought risk reduction efficiency inside and outside the Bang Rakam model**	Impact	Disaster risk reduction	No	--	Flood detention system expected to retain excess water during flooding season, and can assess by detecting the area of water surface inside and outside detention area	GIS map, time-Series satellite imagery both at local area and further downstream, 2017 – 2020 from Sentinel 1	Existing dataset (open access Sentinel 1 imagery)	RS data from Landsat and Sentinel mission

FLOODPLAINS – EXAMPLE INDICATORS

3	**Household income from fisheries**	Outcome (intermediate)	Climate risk reduction (income / job security)	No	--	Majority of households in area rely on fisheries. In the past 10 years, yields have declined and income affected. Decrease due to insufficient of water budget and demand from farming. An increase of income from fishing would contribute to economic wellbeing of household.	Household survey data	Existing secondary data source + questionnaire (primary data from pilot)	Secondary source: Fisheries statistics of Thailand \2009-2018

LIVING WEIRS – EXAMPLE INDICATORS

1	**Sub-surface water level around the upstream and downstream of living weirs**	Outcome (intermediate)	Climate risk reduction (income/job security)	No	--	Living weirs are expected to help maintain sub-surface water level in shallow wells, especially in dry season, as a higher surface water level in canal reduces the hydraulic gradient between shallow wells and canal. Contributes to water for domestic household use.	Positive outcome if, for a given period, an average value of sub-surface water level at upstream of living weirs > at downstream of living weirs.	Site surveying to select observation wells at upstream & downstream; Monitoring sub-surface water level in shallow wells; Time series data plot to analyze relationship between levels in shallow wells & canal at upstream & downstream. Standard method and low cost.	Primary data collection

LIVING WEIRS – EXAMPLE INDICATORS

2	**Species diversity of aquatic insects at upstream and downstream of Living weirs**	Outcome (intermediate)	Cost/Co-benefit (biodiversity/ ecosystem health)	No	--	Diversity of aquatic insects indicates whether environmental change in stream habitat affecting these species. Many macroinvertebrates have relatively short life cycle with multiple generations per year, enabling temporal and spatial analyses, and detection of perturbations. Because also found in high densities in streams, abundance and diversity means at least some will respond to a given environmental change. Positive outcome if the Shannon-Weiner index at living weirs site ≥ 1 (good species diversity) and if both indexes are › than those at control site (far upstream area without living weirs).	Sampled using nets in each sampling area. Stretch of approximately 50 m will be chosen for target habitats: riparian vegetation, leaf litter, low gradient riffles and pools. Sampling time at each habitat is 3 min, 3 replicate samples to be collected at each station, considering all possible microhabitats. Two species diversity indexes including the Shannon- Weiner and the Simpson index will be applied.	Primary data collection	Primary data collection

LIVING WEIRS – EXAMPLE INDICATORS

3	**Number of community activities related to living weirs per year**	Outcome (intermediate)	Adaptive capacity; co-benefit for local governance/ participation	No	--	Indicator for local participation in NRM and the EbA measure. Activities may include living weirs maintenance, cultural events, fish sanctuary, reforestation etc.	Surveying from community leaders and local government; The evaluated by comparison against baseline information.	Primary data collection	Focus group discussion

Annex 2: Summary of stakeholder feedback

The tables below present the results of discussions on the EbA measures with local community leaders and members, as well as the authorities, including through workshops, focus group meetings and household surveys. Feedback covered a range of topics, including the main benefits and trade-offs, on the pilot studies and M&E of EbA, and the design, implementation and future of the EbA measures.

Living weirs

Example benefits identified by stakeholders Water-related benefits	Example problems/trade-offs identified bystakeholders Water-related problems
• Release of water from canals is controlled by the Royal Irrigation Department (RID); villagers need a way to store water, thus water storage ponds and living weirs can help retain and store water. **Environmental benefits** • Villagers feel that the living weirs did not have substantial effects on the ecosystem, except that there are more fish and it helps to retain water for agricultural purposes. **Socio-economic benefits** • Villagers can benefit from the living weirs by using water to grow gardens and durians. Weirs are also important for houses with orchards. On the other hand, villagers who only have rubber plantations do not require as much water.	• The dry season lacks water, and when it rains, the water does not store well (which is one of the challenges the weirs aim to address). • Villagers downstream are concerned that living weirs will cause water shortages for them. • Some villagers are unaware of the role of the weirs, because they do not see the benefits directly. • There are many sago palms, helps with water retention but causes overgrowth, creating obstacles in the canal and shallow canal flooding. **Environmental problems** • The smell of stagnant water in the canal is an issue; this may be due to contaminated water and soil that can accumulate in shallow wells.

Feedback on the M&E / research	Proposals for the weirs, water management & EbA over longer term
• The villagers considered the research to be beneficial; M&E can increase the achievement of impacts and benefits. • Local people benefit from access to water level information, and this information helps to assess the effectiveness of the living weirs. • The app that was developed is user-friendly, but observing the water level from the gauge is difficult in murky water, so users may not do this over the long-term. • Suggest a communication platform where information is updated daily for local people, such as in a Line group. A channel could also be added for pictures and other information on weir conditions. • Exchanges between communities, living weirs building groups and experts (e.g. on trouble-shooting and maintenance) encourages communities to seek funds for maintenance and use living weirs effectively. • Recommendations were made on how to choose monitoring locations, e.g. more points needed for water level measurements. • The villagers are more aware of the importance of M&E, leading to increased engagement and a desire to work with research teams, feeling that the research would help the community develop.	• Rubber trees, gardens, and encroachment around the canal can make them shallow and narrow, so rules are needed to reduce canal encroachment. • Build more living weirs for water retention; an alternative is a soil weir to avoid using sacks (with their risk of microplastics); cement weirs also suggested (though not EbA). • Prioritize water management in the area, because gardening and farming require water and communities need to understand its importance. • Government departments and/or education sectors need to play a role in communicating the importance of living weirs. • Still a lack of wider/ongoing participation; often original living weirs team only is involved in maintenance, and villagers assume they are leaders' responsibility only. Need to raise awareness that community development everyone's concern. • Each village headman should have a list of the weir building teams and caretakers; also encourage youth to join and help with construction & maintenance. • Invite villagers to come together to build and maintain the weirs once a year. • Define fish conservation areas and release fish in front of the living weirs. • A canal meeting should be conducted once a year; and create a canal map to support water management purposes. • Planting more trees along the banks for economic benefits. • Promote the living weirs as a destination for nature tourism; maintain the area so it is attractive, and without weeds. • Request budget for living weirs from the Sub-District Administrative Organization and other government agencies. • Also suggested to widen the canal, as community needs water for farming and agriculture.

Floodplains

Example benefits identified by stakeholders Water-related benefits	Example problems/trade-offs identified bystakeholders Water-related problems
• The result of Ban Rakam Model show that flood risks can be reduced. • The benefit of water supply in dry season in exchange for flood detention in wet season has attracted farmers in Kong subdistrict; most would like to participate in the Bang Rakam Model if the rice benefits outweigh the flooding impacts. • Good water management is the basis for ecosystem conservation, quality of life, economic development, and good relationship between humans and animals. **Environmental benefits** • The soil is good in the area; the flood water will help to wash away the insects and rotten grass in the rice fields, and brings in nutrients for soil. • More floodwater, and more water retained for longer, means more fish. **Socio-economic benefits** • Some villagers support the water detention in the area because it makes fishing an additional source of income, and even request for longer detention period to catch more fish (as it is normally less than 1-2 months). • Flooding reduces the cost of fuel for pumping water into the fields, and the villagers can hold the water in the fields for further cultivation.	• In addition to issuing warnings, the communities need government agencies to visit and see the real situation during flood and drought periods. • In the last 5 years, water in the whole basin was less, so that the water going into flood detention was also less than usual. • Floodwater has negative impacts, such as rotting vegetation (which affects fish), damage to roads, and cost of fuel for boats. • Outside the irrigated areas, water supply is low and insufficient. Sometimes water is diverted according to an inflexible schedule; it can take almost 15 days for the water to arrive to some areas (new floodgate expected to help resolve this problem). • The flooding period can still be quite limited, e.g. just 1 month, and then it dries up, meaning still 2 months before harvest with no water for crops. **Environmental problems** • When there is a flood, the water flows faster, causing the ecosystem to change; the project has changed the ecosystem. • Other environmental challenges include that the original ecosystem of the river has changed because of the road structure, and excessive pumping of groundwater • Forests are not as fertile/productive as in the past.

Example benefits identified by stakeholders Water-related benefits	Example problems/trade-offs identified bystakeholders Water-related problems
	Socio-economic problems • Some villagers disagree with being in the model due to the lack of compensation. • Before the Bang Rakam model, farmers can harvest 3 times a year, but now only 2 times per year is supported under the model. Farmers can harvest more, but this means they will not receive government support for that cycle. • Farmers in the Bang Rakam Model receive irrigation water for rice cultivation in both in wet and dry seasons. But after harvesting there is a gap during which farmers lack income. Many cannot move, so they have to adapt or find more income in this 5-8 month period, such as construction work, general employment, and catching fish. • The income from rice cultivation is generally higher than fishing; farmers in the flood detention areas thus sacrifice income for the greater good. • Conflict over water drainage can occur, e.g. in one area, farmers need water to maintain the rice fields but the fishers needed to drain the water to catch fish. In another, farmers want to release water while fishers want to keep the water level. • Previously they had some marketing support for community products like fermented fish, salted eggs, and fish sauce, but this has been discontinued. • Households with children, women and elderly are less able to fish during the floods, so they lack this extra income. • There are costs for houses damaged during floods, such as repairs, alternative accommodation, etc, and some houses have not been repaired. • People in the water detention areas are in trouble; there are problems with debt and suicide. During the 7 months of flooding at one period, the villagers had no income. The community want the government to reform the policy and provide assistance to flood-affected people.

Feedback on the M&E / research	Proposals for the floodplains, water management & EbA over longer term
• The majority of people surveyed supported the M&E project. • There is some willingness to participate in M&E activities (36.6% of those surveyed in Sukhothai province and 36.7% in Phitsanulok province). • The study team should visit during the flooded period and the dry season to see the range of impacts. • The research team should consider how many people are farming, how many are fishing, and how many do both, along with how to create added value for rice, e.g. higher prices for rice gown in high nutrient soils. • Promote analysis of soil and chemical residues in sediments to plan for planting crops and ensure safety in agriculture and aquaculture.	• RID should not fill soil in the Yom River higher than 2 m, because lower water in the river leads to changes in the ecosystem and fishing for communities. • Water in the dam is limited, leading to water shortages, and this delayed farming/late harvesting. The community want RID to reserve enough water to address this. • Government should support compensation for flooding, and additional occupation/ income for farmers, e.g. processing (such as aquaculture and fish) and marketing. • There should be a year-round market for community products. • Compensation should be calculated based on actual farming costs as the villagers are obliged to sacrifice on behalf of others. • If there is no compensation, then there should be enough water provided for the villagers in every season. • Villagers want roads to be elevated to allow travel during floods, as after flooding, the road level will collapse. • Some recommended other interventions, such as additional dredging of canals & river, repairing broken rubber dam, using excavated soil to fill in roads, building a stepped dam with watergate control to store water in dry season, monkey cheek dam approach, etc. • Some suggested to promote higher ground areas during the flood for tourism and bring in community products to sell at tourist spots, for additional income during flooding.

Feedback on the M&E / research	Proposals for the floodplains, water management & EbA over longer term
	• Tourism needs to be managed well, to avoid negative impacts like noise, drowning risks, etc. • There should be a survey to develop reser voirs and aquaculture; local government should promote water reservoirs such as mini ponds in agricultural areas. • The rice prices for Bang Rakam Model should be higher to compensate for the loss of their livelihoods opportunities. • Government should train people about water management so they understand more sustainable ways to fish and farm, with an agreement to have first phase for fishing, then second phase for rice farming, and third phase for ecosystem conservation. • Suggest a system to pump water from Yom River through the canal by using mobile solar cells to add water to the project. • Should consider planting perennials that are resistant to flooding, such as rubber trees, water olives, etc.

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