P-LINK
People's Livelihoods Initiative
through water-energy-food Nexus
in the MEKONG Region

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus [RoK-UNOSSC Facility Phase 3]

2023 ANNUAL REPORT

Ministry of Science and ICT

MEKONG RIVER COMMISSION
MRC
FOR SUSTAINABLE DEVELOPMENT

United Nations
Office for South-South Cooperation

STEPI
SCIENCE AND TECHNOLOGY POLICY INSTITUTE

MEKONG INSTITUTE

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EXECUTIVE SUMMARY

In September 2021, the Ministry of Science and ICT (MSIT) of the Republic of Korea (RoK), the Mekong River Commission (MRC), and the UN Office for South-South Cooperation (UNOSSC) launched a new project entitled, the "Triangular Cooperation on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus" ["RoK-UNOSSC Facility Phase 3"; Project ID:127005]. In line with Outcome 3 of *UNOSSC Strategic Framework 2022-2025*[1] and *MRC Basin Development Strategy (BDS) 2021-2030*, the project made concerted efforts to analyse development priorities of the Lower Mekong Basin (LMB) countries in supporting the livelihood of riparian communities, especially in contexts where appropriate technologies and innovations could be accessed to address the challenges faced by the communities.

In 2023, the project technically designed the pilots through continuous consultations with the four participating countries (Cambodia, Lao PDR, Thailand and Viet Nam) at the regional, national and local levels. Based on the site visits, partner inputs and request, the technical proposals to better access to water, energy and food in the identified pilot sites were formulated and submitted to partner countries. The proposed technical solutions are tailored to pressing challenges caused by the environmental and socio-economic situation of each site. The innovative approaches of the solutions offered have been acknowledged by the country partners.

The project also convened policy dialogues and offered capacity building through regional forums and training of trainers (ToT). These exchanges served as critical processes to match the local needs and expectations with feasible solutions that could be offered by the project based on the principles of South-South and triangular cooperation (SS & TrC): that is, demand-driven, national ownership, mutual accountability and transparency and multi-stakeholder engagement.

The project also continued to serve as a platform for various development cooperation stakeholders to discuss integrated management of water, energy and food through the Water-Energy-Food (WEF) Nexus approach that encouraged sharing of knowledge and experiences. It produced two publications capturing key observations and lessons learnt from other similar WEF Nexus initiatives. The project also convened seminars with technical experts to dive into WEF Nexus approach and identify its practical application for sustainable local livelihoods, and discuss the conclusions of the knowledge products to inform the project through those research findings.

The project faced institutional changes and transitions of involved entities that often led to miscommunications and delayed coordination. Regardless, the project continued to steadily advance its implementation including finetuning of its original results framework as recommended by the Steering Committee.

On the way forward, the report elaborates key issues and recommendations for effective project management and deliverables in 2024 and onward.

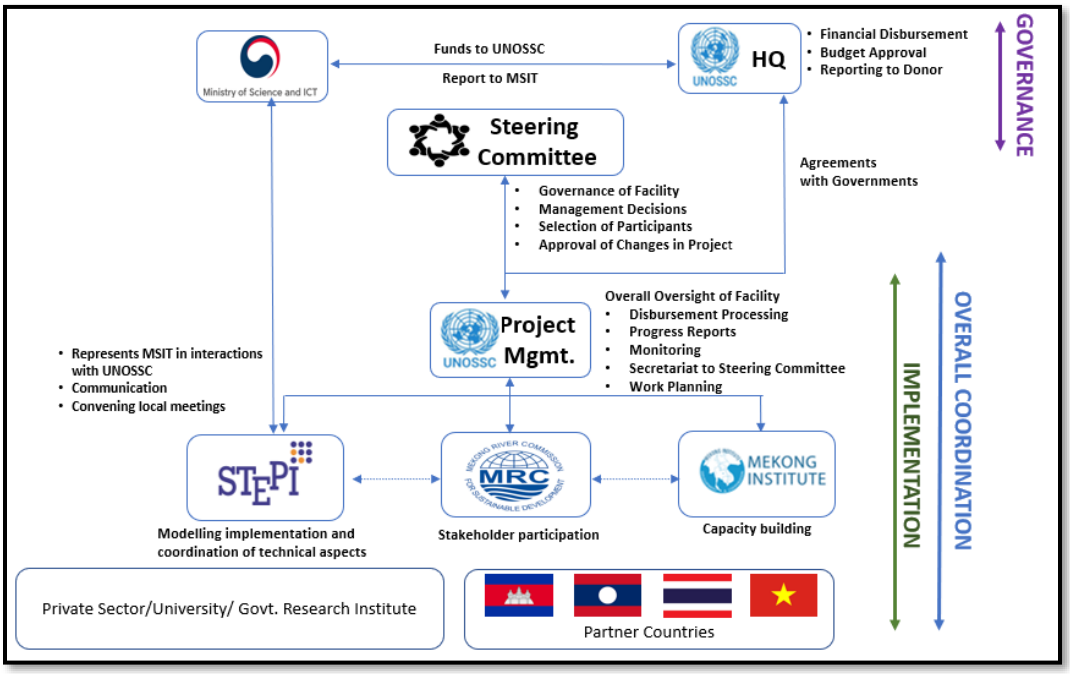
[1] Outcome 3: Developing countries are enabled to implement 2030 Agenda through harnessing South-South and triangular knowledge exchange, capacity building and technology transfer facilitation

CONTEXT

The "RoK-UNOSSC Facility Phase 3" is intended to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. It takes integrative and multi-sectoral approaches in the application of technologies and innovations on water, energy and food to improve the people's livelihoods based on SS & TrC modalities. With such a vision and objectives, the project is referred to as the P-LINK ("People's Livelihoods Initiative through water-energy-food Nexus in the Mekong Region).

The 5-year project with a budget of USD 4 million, is supported by the Ministry of Science and ICT (MSIT) of the Republic of Korea (RoK), and the UNOSSC leads the project implementation in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) of the RoK. In its work, STEPI will also enlist technical expertise of other RoK institutions. Figure 1 shows the implementation structure for the project.

Figure 1: Implementing Structure



The project's outcomes and outputs, to be delivered by 2025 is shown in Table 1. For detailed refined results framework, refer to **Annex 1**. It has been detailed as the specific needs to be addressed by the project and the pilot site selection were finalized in line with the Steering Committee's recommendation. They are partly derived from MRC's *BDS 2021-2030*, taking a demand-driven approach. The project aims to strengthen water, food and energy for vulnerable communities living in the Lower Mekong River Basin. This will be achieved through the following outcome:

- More community members particularly women in the project pilot sites use clean water and renewable energy and diversify the crops.

The core building blocks of the project include 1) Knowledge generation, 2) Multi-Sectoral Platform, 3) Advisory Services, 4) Technology Identification, 5) Capacity Building and 6) SS & TrC.

Table 1: Detailed Finetuned Results Framework

<table>
<tr><th>RESULT STATEMENTS</th><th colspan="2">INDICATORS</th></tr>
<tr><td rowspan="5">Outcome: More community members particularly women in the project pilot sites use clean water and renewable energy, and diversify the crops.</td><td colspan="2"># (%) of people that use clean water (total/female)</td></tr>
<tr><td colspan="2"># (%) of people that use renewable energy (total/female)</td></tr>
<tr><td colspan="2"># (%) farmers that diversified their crops (total/female)</td></tr>
<tr><td colspan="2"># of examples of dev. solutions in SS & TrC transferred to developing countries</td></tr>
<tr><td colspan="2"># of development solutions transferred through the pilots scaled-up</td></tr>
<tr><td rowspan="3">Output 1: Assessments and research conducted, to select pilot projects, building on knowledge and data.</td><td colspan="2"># of case studies produced analyzing WEF Nexus projects</td></tr>
<tr><td colspan="2"># of WEF Nexus project sites identified</td></tr>
<tr><td colspan="2"># of consultative and planning meetings convened</td></tr>
<tr><td rowspan="3">Output 2: WEF nexus models projects designed targeting identified sites leveraging South-South learning & partnerships.</td><td colspan="2"># of WEF nexus models projects designed</td></tr>
<tr><td colspan="2"># of stakeholders engaged during WEF nexus models projects design</td></tr>
<tr><td colspan="2"># of people engaged during WEF nexus models projects design (total/female)</td></tr>
<tr><td rowspan="11">Output 3: WEF nexus pilots implemented in participatory manner.</td><td colspan="2"># of WEF pilot projects implemented</td></tr>
<tr><td rowspan="5">Direct beneficiaries</td><td>Total (female):</td></tr>
<tr><td># (%) of people received capacity building training (total/female)</td></tr>
<tr><td># (%) of people with better access water (total/female)</td></tr>
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<tr><td rowspan="3">Output 4: Advocacy & knowledge products developed & disseminated to promote SS & TrC exchanges.</td><td colspan="2"># of advocacy and knowledge products developed and disseminated</td></tr>
<tr><td colspan="2"># of SS & TrC exchanges facilitated</td></tr>
<tr><td colspan="2"># of people participated in advocacy events (total/female)</td></tr>
</table>

Specific activities for 2023 include the following:

1. Implement recommendations of the Second Steering Committee (SC) Meeting (finetune results framework)
2. Finalize and disseminate knowledge products (case studies) on WEF nexus related initiatives in the LMB and other regions capturing achievements and lessons learnt to be incorporated into P-LINK
3. Convene regional and national consultations with partner countries to learn the local needs and challenges and identify technologies needed to solve the problems
4. Convene the first regional training of trainers on WEF Nexus
5. Propose technical solutions to design the national pilot in respective countries
6. Explore collaborative opportunities with other initiatives and networks related to water, energy and food
7. Increase project visibility and advocacy
8. Incorporate lessons learnt from the RoK-UNOSSC Facility (Phase 2) throughout the implementation

PROGRESS REPORT FOR 2023

2023 Activities

Table 2 captures key activities carried out in 2023.

Table 2: Snapshot of major activities in 2023

No	Date	Event/Activity	Remarks
1	Jan 26	*Pilot Design* Thailand:1st National Consultative Forum	Learnt about Thailand's 15-year national project to support its civil society networks in the 8 provinces along the Mekong River.
2	Jan 27	*Project Mgmt.* 2022-2023 Work review and planning workshop (INTERNAL)	Review the project progress and prepared 2023 workplan and reporting for the SC
3	Feb 2	*Governance* 2nd SC Meeting	Project Mgmt. presented outstanding issues & proposed annual work plan to SC Members. Refer to Annex 2. (Media Brief)
4	Mar 6-7	*Pilot Design* Viet Nam: Visit to a new proposed pilot site and consultation with local stakeholders	Investigated the local situation with a ROK technical expert to cope with salinity and water mgmt.
5	Apr 21	*Pilot Design* Technical Meeting with ROK experts in designing national pilots	STEPI convened a discussion with ROK technical experts to prepare technical proposals for each national pilot
6	May 4	*Advocacy* "Policy challenges from multi-level perspectives to accelerate the full implementation of STI for SDGs"	During the sidelines of 2023 STI Forum (Media Brief)
7	July 18-20	*Advocacy* ADB Policy Dialogue Towards a GMS-wide Policy Platform for Climate Change Adaptation & Disaster Risk Mgmt.	MI shared about P-LINK experiences
8	Aug 31	*Policy Dialogue* 2nd Regional Stakeholder Consultative Forum	See Annex 3 for results of consultation. Countries shared local development challenges of their identified pilot sites and STEPI proposed about the possible technical solutions. (Media Brief)
9	Sept 8	*Advocacy* 2nd Mekong-Korea International Water Forum	STEPI introduced P-LINK about the applied Nexus approach and SS & TrC modality
10	Sept 14	*Advocacy* SEI Regional Roundtable on "Building Climate Resilience in the Mekong Region: Bridging Science, Policy, & Practice"	MI introduce P-LINK and its implementation modality
11	Oct 16-19	*Capacity Building* 1st Training of Trainers (ToT)	Theme: Advancing Water-Energy-Food (WEF) Nexus Pilot Implementation in the Lower Mekong Basin. Refer to Annex 5. (MI Media Brief & UNOSSC Media Brief)
12	Oct 20	*Pilot Design* Thailand: Visit to a new proposed pilot site through local consultation	Conducted site analysis by a ROK technical expert for a smart water mgmt. system.
13	Jul-Oct	*Pilot Design* Technical proposals for partner countries submitted to respective NMCs	STEPI prepared technical proposals and submitted to NMCs for their review.
14	Dec 7-8	*Pilot Design* Viet Nam: 2nd National Consultative Forum and Visit to proposed pilot site led by VNMC	Demonstrated national ownership to expedite the official endorsement to kick-start the pilot in the project site. VNMC provided an update of the project progress, introduced the technology proposal for its site and rationale for such approach to its national and local stakeholders engaged in the project.

Main Adjustments to Project Implementation

On February 2, the Second Steering Committee Meeting was convened. At the meeting, the Steering Committee endorsed the new structures of the Steering Committee and the Project Management as well a postponement of the mid-term evaluation. In parallel, it recommended refinement of the project results framework. The further detailed results framework (Annex 1) includes indicators reflecting the linkage between local pilots and regional policy frameworks and specific indicators to measure the progress and impact of the national pilots. This framework has been acknowledged by partner country stakeholders with no objection during the Second Regional Stakeholder Forum on August 31. Table 3 illustrates the progress made under each output under the refined framework. Detailed figures related to pilot implementation will be available from the end of 2024 with their further progress.

Table 3: Key deliverables from 2021-2023 aligned with the detailed results framework

Outcome: More community members particularly women in the project pilot sites use clean water and renewable energy and diversify the crops.		
Indicators		**#**
No. (%) of people that use clean water (total/female)		To be collected from 2024
No. (%) of people that use renewable energy (total/female)		
No. (%) of farmers that diversified their crops (total/female)		
No. of develop. solutions transferred via the pilots scaled-up		
No. of examples of dev. solutions in SS & TrC transferred to developing countries		4 solutions
Outputs	**Indicators**	**#**
Output 1: Assessments and research conducted, to select pilot projects, building on knowledge and data.	No. of case studies produced analyzing WEF Nexus projects	4
	No. of WEF Nexus project sites identified	4
	No. of consultative and planning meetings convened *(national, regional & RoK tech consultations, site visits, trainings, advocacy events)*	23
Output 2: WEF nexus models projects designed targeting identified sites leveraging South-South learning and partnerships.	No. of WEF nexus models projects designed *(Refer to Table 4 & Annex 4)*	4
	No. of stakeholders engaged during WEF nexus models projects design (Project Team, NMCs , local govts., ROK experts)	16 (ongoing)
	No. of people engaged during WEF nexus models projects design (total/female)	Ongoing
Output 3: WEF nexus pilots implemented in participatory manner.	No. of WEF pilot projects implemented *(Refer to Table 4 & Annex 4)*	4 (ongoing)
Output 4: Advocacy and knowledge products developed and disseminated to promote SS & TrC exchanges.	No. of advocacy and knowledge products developed & disseminated	2
	No. of SS & TrC exchanges facilitated *(national, regional consultations, site visits, trainings, advocacy events)*	30
	No. of people participated in advocacy events (total/female)	243 (107)

Detailed Pilot Design and Implementation

Following further site investigations and consultations particularly for Lao PDR, Thailand and Viet Nam, the Project stakeholders reached a consensus on the initial pilot design modality and technical solutions. As of date, the project a set of confirmed pilot sites and solutions as shown on Table 4. At the Second Regional Forum, the National Mekong Committee (NMC) delegations presented basic demographics about respective identified pilot sites and shared about the pressing development challenges faced by local communities related to access and management of water, energy and food. ROK technical experts proposed most suitable innovative solutions to be applied in the local context. The forum also facilitated technical exchanges and knowledge sharing leading to productive discussion on detailed pilot implementation action plans.

Table 4: Pilot Design and Implementation Status

Country	**Site**	**Project Title**	**Tech Solutions**[2]
Cambodia	Sdao Commune, Stung Treng	Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng	Solar power generated water treatment system
Lao PDR	Vientiane and Nakio Village in Mahaxy District, Khammouane Province	Integrated water mgmt. via centralized national facilities and enhanced local flood forecasting and early warning system in Xebangfai river basin in Khammouane Province	Advisory services on mid-term and long-term roadmap, data quality improvement, etc.
Thailand	Bung Khla Sub-district, Bueng Kan Province	Increasing the Efficiency of Tap Water System in Moo[3] 1,2 and 3 Bung Khla Sub-district, Bueng Kan Province	Smart Water Mgmt. System
Viet Nam	Con Linh (Linh Island), Giog Trom District, Ben Tré Province	Improvement of Livelihoods through the Application of WEF Nexus Approach in the Mekong Delta of Viet Nam	Saline groundwater desalination system generated by renewable energy

As recommended by the partner countries, the Project prepared a "National Pilot Information Note" template (Annex 6) to facilitate partner countries' stakeholders in introducing the project to its national and local stakeholders for official endorsement to kick start pilot implementation on the ground.

Furthermore, the template served as a learning mechanism for project stakeholders to deepen their understanding about the WEF nexus as well as contribute to their country pilot design. At the First Regional Training of Trainers (ToT) organized by the Mekong Institute on October 16-19 under the theme of "Advancing Water-Energy-Food Nexus Pilot Implementation" in the Lower Mekong Basin, trainees from the four countries prepared a draft information note for their pilots with special focus on the "situational analysis". (Refer to Annex 5: Training Completion Note)

[2] Annex 4: Detailed technical solutions submitted to partner countries

[3] Moo means village in Thai

In addition, in the last quarter, basic survey arrangements were made by UNOSSC, STEPI and MRCS jointly with each NMCs to take stock of the current situation of water, energy and food management in identified pilot site and collect relevant baseline. (Refer to Annex 7: National Pilot Basic Survey Concept Note)

Project Visibility and Advocacy

In 2023, the Project Team showcased the project's modality and approach in applying WEF nexus in the Mekong subregion in various knowledge sharing and networking occasions including the 2nd Mekong-RoK International Water Forum and the ADB Policy Dialogue Towards a GMS-wide Policy Platform for Climate Change Adaptation and Disaster Risk Management.

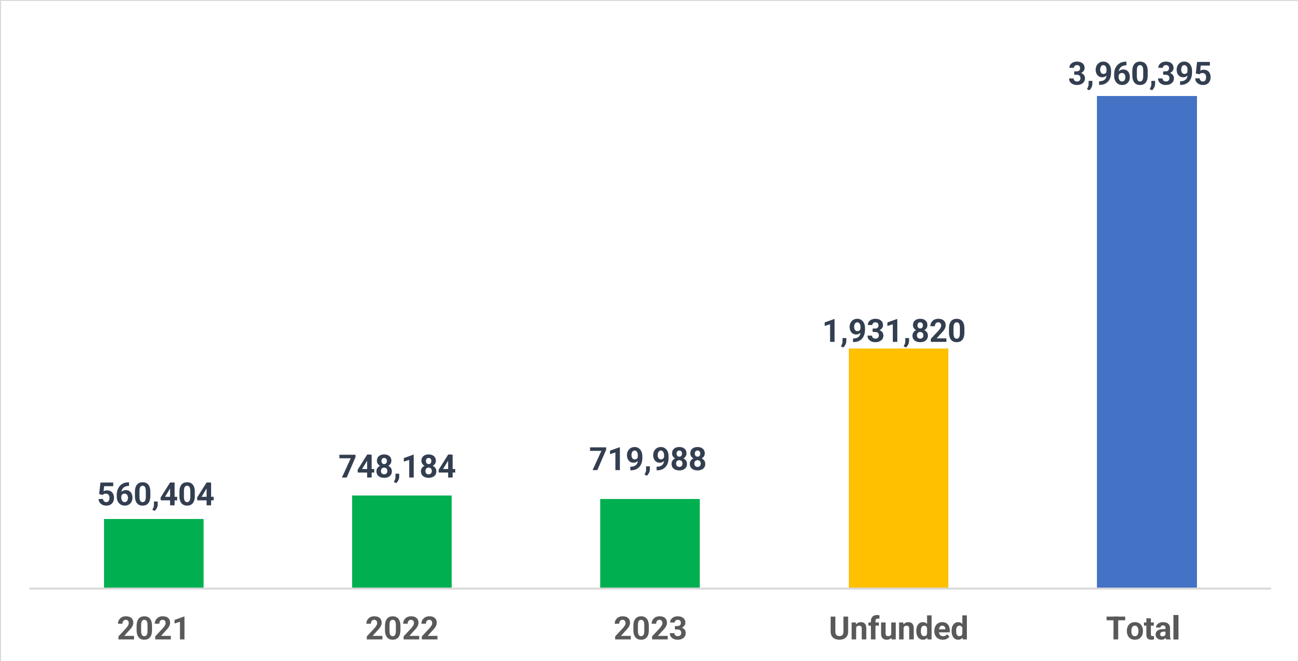
On the sidelines of the 8th Multi-stakeholder Forum on Science, Technology and Innovation (STI) for the Sustainable Development Goals (2023 STI Forum), a policy dialogue was convened to review the progress and challenges of integrating STI into national, regional and global development agenda. The integrated work, ranging from advisory services, advocacy, and fund management to field projects including the mapping of South-South cooperation on STI and the RoK-UNOSSC Facility on the water-energy-food nexus in the Mekong Region through science and technology (P-LINK) was introduced during the session.

In parallel, the Project Team acknowledged to invest more efforts to showcase the project with tangible results from the four national pilots towards the second half of 2024.

FINANCIAL STATUS

As of January 2024, the Government of the Republic of Korea (RoK) has contributed a total of ***USD 2,028,575.21***. The Ministry of Science and ICT (MSIT) made ***three*** installments of USD 560,403.84 (KRW 655,000,000) in September 2021, USD 748,183.65 (KRW 968,000,000) in June 2022 and USD 719,987.72 (KRW 938,000,000) in June 2023. An additional ***USD 1,931,819.79*** will be allocated to the project in the upcoming two years (2024-2025).

Figure 3: P-LINK Financial Status – Funds received and pending



CHALLENGES AND ISSUES

1. **Multi-stakeholder coordination**
   Triangular cooperation brings together a wide range of stakeholders to complement South-South Cooperation. It may not offer simple structures to advance sustainable development, its richness in partnerships provides singular and valuable spaces for experimentation and co-decision making. As such, the project had benefitted from its broad multi-stakeholder engagement but also been challenged on the timely delivery of its workplan.

   Underscoring that nationally owned approaches are at the core of South-South cooperation, the project allowed a longer time for the regional and national consultation for decision-making and moving forward.

2. **Clear roles and responsibilities & timeline arrangements in piloting a new approach**
   The project faced bottlenecks of multi-stakeholder coordination especially bringing together four partner countries as well as the ROK technical experts and the Project Team. Often there are too many actors involved for final decision-making. Despite advance planning, it took more time to confirm the meeting dates. In addition, partner countries' stakeholders faced challenges in devoting time and dedication into this project among their daily responsibilities and other priorities. For this reason, it took more time to develop the pilots' design and prepare for the official endorsement processes. Some stakeholders are new or unfamiliar to the RP roles assigned to them in this project, hence they sometimes tend to revert implementation responsibilities to the project management team. This has been addressed during the project review and plan meeting in Jan 2024 and hope to help resolve the challenge moving forward.

3. **Changes and delays in administrative and operational arrangements**
   In 2023, UNDP launched a new digital platform known as Quantum as its internal control framework. It took some time for the project to adjust to the new institutional financial and operational rules and regulations.

   As financial allocations are disbursed each year from MSIT to UNOSSC, the Letters of Agreement (LoAs) signed with respective institutions must be revised annually to include the new resources. The reason for this is that UNOSSC cannot commit to allocate to IP's resources that it does not yet have. Therefore, LoAs had to be revised to meet the requirements of respective institutions.

   In addition, as part of the Project Management Team relocated to New York, the Project Manager also had to execute additional operational and financial tasks without the presence of the Programme Associate who used to support the project as well. Supervisory, operational, financial and oversight support by UNOSSC begun to be provided through their Office in New York. While this enabled some agilities, and offered the support of a broader set of colleagues, it also presented a set of new challenges, including time zone differentials.

4. **Postponing roll out of pilots and the mid-term evaluation**
   Delays in planned activities including basic survey completion, official roll out of the pilot, and the mid-term evaluation schedule. The Project Team is considering to change the mid-term evaluation modality as an internal self- review after technical facility installments in the four pilots, given the time proximity to the final evaluation.

WAY FORWARD AND RECOMMENDATIONS

In the wake of the issues raised the following are recommended for the implementation of the project in 2024.

1. **Seeking for greater ownership and leadership by national and local stakeholders**

   The project requires concerted commitment and ownership by the national and local stakeholders. The Project Team will continue to seek for national and local guidance and ownership of the project to enhance livelihoods of their communities.

2. **Expedite pilot roll out and implementation**

   In line with the endorsed 2024 work plan, the Project Team (UNOSSC & 3RPs) to deliver tangible progress on the pilot implementation and document achievements and lessons learnt accordingly.

3. **Develop exit plan for pilot sustainability and scalability**

   Along with day-to-day project implementation, the Project Team in consultation with national and local stakeholders in each country should consolidate and implement action plans for project sustainability and scaling-up.

4. **Showcase tangible project achievements and successful factors in advocacy events**

   The project should explore strategic partnerships with other development stakeholders by showcasing real impact of the pilots and key success factors.

Annex 1

version as of 4 August 2023

Finetuned Results Framework of RoK-UNOSSC Facility (Phase 3)

The RoK-UNOSSC Facility (Phase 3)'s outcomes are aligned with the Basin Development Strategy (BDS) 2021-2030 of the Mekong River Commission as follows:

Outcome 1: Strengthened water, energy and food security for basin community wellbeing.

Outcome 2: Increased employment and reduced poverty among vulnerable people dependent on river and wetland resources.

Outcome 3: South-South and triangular cooperation approached used to facilitate quick transfer and adaptation of development solutions and technology applications conductive for supporting development solutions against gender-related and other disadvantaged groups across.

RESULT STATEMENTS	INDICATORS	DATA SOURCE	BASELINE[1]	TARGETS (cumulative)					DATA COLLECTION FREQUENCY
				Year 1/ 2022	Year 2/ 2023	Year 3/ 2024	Year 4/ 2025	FINAL	
Outcome: More community members particularly women in the project pilot sites use clean water and renewable energy, and diversify the crops.	Number (%) of people that use clean water (total/female)	Beneficiaries' Assessment[2]	2023	N/A					Annual
	Number (%)of people that use renewable energy (total/female)	Beneficiaries' Assessment[3]	2023	N/A					Annual
	Number (%) farmers that diversified their crops (total/female)	Beneficiaries' Assessment[4]	2023	N/A					Annual
	Number of examples of development solutions in SS & TrC transferred to developing countries	Case studies on transfer of development solutions[5]	2023						Annual
	Number of development solutions transferred through the pilots scaled-up	New development initiatives rolled out from national pilots (e.g. regional collaboration, linkage with UNCTs, other develop. partners)	2023	N/A	N/A	N/A			Annual
Output 1: Assessments and research conducted, to select pilot projects, building on knowledge and data.	Number of case studies produced analyzing WEF Nexus projects	Case Study Reports	2021			N/A	N/A		Annual
	Number of WEF Nexus project sites identified	Project Database	2022			N/A	N/A		Quarterly
	Number of consultative and planning meetings convened	Project Database	2021						Quarterly
Output 2: WEF nexus models projects designed targeting identified sites leveraging South-South learning and partnerships.	Number of WEF nexus models projects designed	Project Database	2023	N/A		N/A	N/A		Quarterly
	Number of stakeholders engaged during WEF nexus models projects design	Project Database	2023			N/A	N/A		Quarterly
	Number of people engaged during WEF nexus models projects design (total/female)	Project Database	2023			N/A	N/A		Quarterly

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[1]Baseline required: options pre/post survey, or tapped into mid-term evaluation with regular monitoring activities.

[2] Best available figure estimate to be provided by local authorities where non-available data will rely on STEPI/RoK institutions' focused group survey.

[3] ibid

[4] ibid

[5] All knowledge products produced by the project can be reflected.

Output 3: WEF nexus pilots implemented in participatory manner.	Number of WEF pilot projects implemented		Project Database	2023	N/A					Quarterly
	Direct beneficiaries :	Total (female):	Project Database	2023	N/A					Quarterly
		Number (%) of people received capacity building training (total/female)	Project Database	2023	N/A					Quarterly
		Number (%) of people with better access water (total/female)	Project Database	2023	N/A					Quarterly
		Number (%) of people with better access energy (total/female)	Project Database	2023	N/A					Quarterly
		Number (%) of people received agriculture support	Project Database	2023	N/A					Quarterly
	Indirect beneficiaries :	Total (female):	Project Database	2023	N/A					Quarterly
		Number of people received capacity building training (total/female)	Project Database	2023	N/A					Quarterly
		Number (%) of people with better access water (total/female)	Project Database	2023	N/A					Quarterly
		Number of people (%) with better access energy (total/female)	Project Database	2023	N/A					Quarterly
		Number (%) of people received agriculture support (total/female)	Project Database	2023	N/A					Quarterly
Output 4: Advocacy and knowledge products developed and disseminated to promote SS & TRMC exchanges.	Number of advocacy and knowledge products developed and disseminated		Advocacy and knowledge products	2021						Annual
	Number of SS & TRMC exchanges facilitated		Project Database	2021						Annual
	Number of people participated in advocacy events (total/female)		Project Database	2021						Annual

27 February 2023

Second Steering Committee Meeting for Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus [RoK-UNOSSC Facility Phase 3] (Project ID: 00127005)

Meeting Minutes

Date: 2 February 2023
Venue: Hybrid meeting (Lotte Seoul Hotel, Seoul, Republic of Korea)
Agenda: Refer to Annex 1
Participants: Refer to Annex 2
Meeting photos: https://bit.ly/3HWYmdp

Opening Remarks

Ms. Eunyoung Jang, Director of Multilateral Cooperation Division, International Cooperation Bureau at the Ministry of Science and ICT (MSIT) and the Steering Committee Co-Chair welcomed the meeting participants especially Ms. Xiaojun Grace Wang, Director a.i. of the UN Office for South-South Cooperation (UNOSSC) and the interim Chair of the Steering Committee, and Dr. Truong Hong Tien, Deputy-Director General, Viet Nam National Mekong Committee (VNMC) joining the meeting on behalf of Mrs. Nguyen Thi Thu Linh. She also thanked the Science Technology and Policy Institute (STEPI) and the Project Management Team for organising the meeting.

Ms. Jang highlighted that the "Water-Energy and Food (WEF) Nexus" was identified as one of the eight (8) pillars of technology and development at the *27th Conference of the Parties (COP 27)* held in 2022. In this regard, Ms. Jang wished the RoK-UNOSSC Facility (Phase 3) to play a catalytic role in addressing climate change and supporting vulnerable communities in the Mekong River basin. She also advised the project to strive to create differentiated outputs from other similar initiatives carried by other development stakeholders in the region. Furthermore, she underlined key deliverables to be achieved in 2023 including knowledge products and kick-off of national pilots in the four participating countries and encouraged the project team to put concerted efforts to deliver the expected outputs this year. She requested UNOSSC to continue to accord high-levels of attention to the project. She looked forward to the joint review of the project progress in 2022 and to review the proposed workplans for 2023.

Ms. Xiaojun Grace Wang, UNOSSC Director a.i., and the interim Chair of the Steering Committee welcomed all participants. Ms. Wang shared with the meeting that the longstanding collaboration has been well recognized by the international community. The "RoK-UNOSSC Facility" has been cited as a good example to champion Triangular cooperation (TrC) for sustainable development on the *2022 Report of the UN Secretary-General on the State of South-South Cooperation*. The project has also been highlighted at the Organisation for Economic Co-operation and Development (OCED)'s *International Meeting on Triangular Cooperation at the Centre of the Global Development Agenda* in October 2022 as well as at the *G20 Leaders' Summit Side event entitled, Enabling Inclusive Development through South-South and Triangular Cooperation* in November 2022. She expressed UNOSSC's sincere gratitude to the Government of the Republic of Korea (RoK), particularly the Ministry of Science and ICT (MSIT) for supporting the project and great partnership with UNOSSC since 2011. She extended her appreciation to the partner countries' guidance and engagement in the project through its National Mekong Committee (NMCs) and the Mekong River Commission Secretariat (MRCS). She also thanked STEPI for hosting the event in Seoul as well as all the implementing parties and the Project Management Team for the commitment to deliver results.

With reference to the alternative project name, "P-LINK", an acronym for "People's Livelihoods Initiative through water-energy-food Nexus in the Mekong Region", the Chair reiterated the project vision and objectives, which is to enhance the livelihood of riparian communities, especially in contexts where appropriate technologies and innovations could be accessed to address the challenges faced by the communities. She stressed the purpose of the meeting in reviewing the concerted work carried out to support the region. All the activities carried out in the previous year including knowledge creation, advisory services and consultations should not just be considered as processes but as mechanisms to match the local needs with feasible solutions that the project could offer based on principles of South-South and Triangular Cooperation (SS & TrC): solidarity, demand-driven, national ownership and accountability. She wished that the project could contribute to tackle challenges faced by communities through effective cooperation and collaboration. Hence, the project cannot be successful without the guidance and support from the 4 partner countries of the Lower Mekong Basin (LMB). She underlined it is a critical time for the Steering Committee to lend advice to issues that require strategic decision-making.

On behalf of Mrs. Nguyen Thi Thu Linh, MRC Joint Committee Chairperson for 2023 and the project Steering Committee member representing LMB countries, Dr. Truong Hong Tien delivered the welcome remarks. Dr. Tien welcomed all participants and commended the good progress delivered up to date. Dr. Tien shared his direct project engagement experiences at the First National Consultative Forum and visit to proposed pilot sites in Mekong delta of Viet Nam (September 2022). He took note of the objectives and methods through which the project tried to learn and understand the local needs at the community level. In parallel, he stressed the urgency of expediting the implementation progress in line with the given timeline indicated in the project document. Therefore, he encouraged the project to identify a feasible solution to accelerate the progress and kick of the national pilots to bring tangible outputs for the people in the four partner countries whose livelihoods have been affected by climate change. Dr. Tien emphasized that the Mekong River Commission, its Secretariat and NMCs work hard to facilitate the coordination of the project so that the expected outcomes and outputs can be delivered before project completion.

Adoption of the Agenda

The proposed Agenda (Annex 1) for the meeting was adopted, without any other business recommended for inclusion.

Note: The meeting fulfilled the minimum requirements for a quorum as laid out in the project document.

Agenda Item 1: Project Overview, 2022 Work Progress, 2023 Work Plan and Suggested Ways Forward

The Project Management Team briefed the Steering Committee in three sections (Refer to Annex 3: Project Mgmt. PPT). Firstly, Mr. Denis Nkala, Chief of Intergovernmental and UN Systems Affairs at UNOSSC walked through the overall project implementing structure, recaptured the decisions of the Steering Committee in the First Meeting, and reported on the financial status as well as milestones since the Project Appraisal Committee (PAC) meeting in June 2021.

Secondly, Ms. Yejin Kim, Project Manager reported on the 2022 work progress and presented proposed 2023 work plan to be endorsed by the Steering Committee. Under Output 1, STEPI produced a knowledge product compiling three case studies on other projects and initiatives taking a WEF Nexus approach to draw key lessons to be incorporated when rolling out the national pilots. Also, the Mekong Institute (MI) produced a study explaining the linkages of the WEF Nexus approach with COVID-19 recovery, build back better and SSC. MRCS and UNOSSC together with NMCs convened regional and national consultative forums and field visits to proposed pilot sites in Cambodia, Lao PDR and Thailand in line with Outputs 1 and 2.

Under Output 2, the pilot sites for Cambodia and Lao PDR have been selected. Further details of the locality, challenges and possible technical solutions are described in the annual report. For Viet Nam, the Project will arrange a follow-up consultation and field visit to finalise the pilot selection by Q1 2023. In the case of Thailand, the country is willing to share its experience on implementing projects in its eight provinces bordering the Mekong river - *Strengthening Civil Society Network in Eight Provinces along the Mekong River*. The Project Manager noted that the Project Team is still closely consulting with Thai stakeholders on its national pilot design and local demand as they request for "tangible outputs". Hence, the pilot modality and approach may be differentiated for Thailand. The Project Team will update the Steering Committee as soon as Thailand makes its decision on the pilot arrangement.

To increase project visibility and advocacy, the project convened a panel session on the role of science and technology in the WEF Nexus during the 2022 Global South-South Development (GSSD) Expo.

The Project Management kindly requested the Steering Committee to allow additional time to finetune the project indicators that had been scheduled to be completed in Q4 2022. The work has been ongoing, but the project spent some time to consult with various stakeholders in the four countries and faced some constrains from unexpected external and internal risk factors.

2023 Work Plan

In 2023, the project will roll-out national pilots, enlisting technical expertise from the RoK institutions led by STEPI. When starting the national pilots, national consultative forums will be organized in each county. Also, the Second Regional Stakeholder Consultative Forum will be held under the theme of "Mutual understanding of the process of the WEF Nexus in the P-LINK project" in June. This MSP will facilitate the technical progress, reinforce networking, present the knowledge products developed and explore linkages between the national pilots and regional work to create synergies aligned with the *MRC Basin Development Strategy 2020-2030*. Following the Regional Forum, the First Regional Capacity Building Training Workshop will be led by MI. According to the project document, a mid-term evaluation was planned to be delivered by June 2023, for which the Project Team requested and the project Steering Committee granted an extension through first quarter 2024.

Table 1: Summary of 2023 Work Plan (Year 3)

Output	**Activities**	**Remarks**
Mgmt.	2nd Steering Committee	2 February 2023
Output 2	Finalize selection of national pilots (STEPI)	Finalization of the pilot sites consisting of: - Physical location of the site - Technology solutions identified - Supporting RoK institutions identified
Output 3	Roll out national pilots (STEPI)	Beginning of Q3 (confirm STEPI procurement/contract modality)
Output 3	National Consultative Forums (MRCS)	1 national consultative forum per country when pilots kick-off
Output 2	Second Regional Consultative Forum (MRCS) - Theme: "Mutual understanding of the process of the WEF Nexus in the P-LINK project	Early June 2023 - Technical progress - Reinforce the networking - Present the knowledge products developed - Linkages of national pilots & regional work
Output 2	First Regional CB Training (MI)	2~3 participants from each country (time and venu- TBC) National pilot design and indicators Selection of common intervention topic for discussion (case study/knowledge/capacity building)
Visibility/ Advocacy/ Partnership	Increase project visibility + explore collaboration with other partners (UNOSSC)	To develop a visibility package (leaflet, brochure) for the project such as GMS Agriculture Ministers Meeting (Q4), explore possibility to organize a technical session; as well as to explore opportunities during LDC5, STI forum (side event), HLC on SSC; UN Day on SSC (Sep 12)
M&E	Mid-term evaluation (UNOSSC)	Request for an extension to the SC (2024 Q1)

Lastly, Mr. Nkala elaborated on the challenges and issues faced by the project as listed below:

- Refining the results framework;
- Changes and delays in administrative/operational arrangements;
- UNOSSC restructuring and transition;
- National Consultation Processes and different expectations of partner countries;
- Communication challenges; and
- Postpone mid-term evaluation (originally scheduled to be completed in June 2023 in the project document).

Particularly, he noted that one of the reasons to convene this Steering Committee meeting in the first quarter is to inform the meeting on the institutional changes of UNOSSC. In addition, he emphasized that national consultative processes and expectation of partner countries had ranged from country to country, and which is important for the project in taking a demand-driven approach. As an example, some countries had submitted proposals for a large-scale infrastructure project following the consultations. Then the Project Team had to get back to the countries to clarify and emphasize again that P-LINK is more focused on capacity building rather than building new infrastructure. For the mid-term evaluation, he suggested that it would be better to schedule at the end of 2023 Q4 rather than in Q2 because the project would have implemented sufficient activities on the ground to be assessed.

On the way forward, he requested the Steering Committee to lend advice on the successor arrangement in relation to UNOSSC's restructuring. He also explained to the meeting on the rationale of not creating another Multi-Stakeholder Platform (MSP) that could be replaced by the Regional Stakeholders Forum that MRCS is leading. Pertaining to the reconciling local pilot activity and regional intervention, Mr. Nkala stressed the importance of linking the national level work with the regional plans. He suggested that a study may be beneficial to examine how the national pilots could be scaled up in line with the regional development frameworks.

Agenda Item 2: Detailed 2022 Work Progress and 2023 Work Plan by Implementing Parties (STEPI, MRCS, MI)

- *Science and Technology Policy Institute (STEPI)* (Refer to Annex 4: STEPI PPT)
  Dr. Hwanil Park, Chief Director, Office of Multilateral Research, Division of Global Innovation Strategy at STEPI recaptured major observations and lessons drawn from the selected three cases of WEF Nexus initiatives under Output 1 as shown in Table 2. The analysis was compiled as one publication and will be finalized in Q1.

Table 2: Lessons learnt for P-LINK from the three WEF Nexus projects

<table>
<tr><th></th><th>Project</th><th>Key stakeholders</th><th>Lessons learnt for P-LINK</th></tr>
<tr><td>1</td><td>Case study of Nexus in Korea and utilization for LAC countries (Colombia, Uruguay, Dominican Republic)</td><td>K-Water, IDB</td><td rowspan="3">- Taking demand-driven and decentralized approaches throughout the project by promoting national ownership and regional cooperation (MRC);
- Setting up clear goals in the planning phase to facilitate effective communications with all stakeholders;
- PLINK pilots to be carefully designed to ensure technical applicability and economic viability within each local context, allowing for private sectors' participation;
- Developing appropriate indicators for each pilot to help effective monitoring and evaluation;
- Preparing strategic exit plans to scale-up national pilots.</td></tr>
<tr><td>2</td><td>Water and Energy for Food (WE4F)</td><td>EU, BMZ-GIZ, Sweden, Netherlands, USAID</td></tr>
<tr><td>3</td><td>Urban Nexus</td><td>UNESCAP, GIZ, ICLEI</td></tr>
</table>

Last year, STEPI focused on knowledge and explaining sharing with partner countries and other stakeholders working on similar WEF Nexus related work throughout all consultative processes. Specifically, STEPI explained the WEF nexus concept in relation to the Integrated Water Resource Management (IWRM) to partner countries and showcased some of the technology and innovations that the Republic of Korea (RoK) applies for integrated management of water, energy and food. STEPI also took the lead in organizing the project's first visibility and networking event on the sidelines of the 2022 GSSD Expo.

In addition, STEPI participated in regional and national consultative forums and field visit to proposed pilot sites to learn the local demands and identity feasible appropriate technologies and innovative solutions that the national pilots may offer to the communities. Dr. Park noted that the proposed pilot site in Cambodia and Lao PDR are inland while the proposed locality in Viet Nam is the river delta of the Mekong. As reported by the Project Management, local demands vary because countries are at different development levels.

Building on the desk review and consultations conducted in 2022, STEPI will prepare to roll out national pilots by Q3 2023. Table 3 shows the planned workflow of STEPI this year.

Table 3: STEPI's 2023 Work Plan

Output/Type	**Activity**	**Timeline**
1 (knowledge)	Case study publication	Q1
2 (pilot development)	Finalise pilot site selection for Viet Nam	Q2
2 (pilot development)	Confirm Thailand's role and pilot project arrangement	Q2
2 (nexus pilot development)	Convene project seminar with RoK institutions	Q2
2 (pilot development) and 3 (pilot implementation)	Select RoK institutions to implement national pilots	Q2
3 (pilot implementation)	Roll out national pilots	Q3

- *Mekong River Commission Secretariat (MRCS)* (Refer to Annex 5: MRCS PPT)
  Mr. Youpheng Long, Communication Officer for Press at MRCS delivered the presentation on behalf of Mr. Santi Baran, Chief of Strategy & Partnership Officer, Office of CEO. Mr. Long highlighted the First Regional Stakeholders Consultative Forum helped all stakeholders to learn about P-LINK including expected roles of respective institutions. Furthermore, he noted that the regional stakeholders to recognize the shared common views to support transboundary cooperation. MRCS also liaised with the National Mekong Committees (NMCs) to convene national consultations and visits to proposed sites in each country, which is a critical step in identifying the technology and innovations to be deployed.

  In 2023, MRCS will continue to facilitate the consultative process between the partner countries and the Project Team so that the pilots could be rolled out as planned. Detailed plan is captured in Table 4.

Table 4: MRCS's 2023 Work Plan

Output/Type	**Activity**	**Details**
2 (pilot development)	Convene 2nd Regional Consultative Forum (June 2023)	- Theme: "Mutual Understanding of the Process of the WEF Nexus in the P-Link Project"; - Present and discuss knowledge products (i.e. case studies, documents) conducted in 2022 on WEF Nexus related initiatives in the LMB and other regions to draw lessons learned to be applied for P Link national pilots; - Discuss technical progress and observations of the project/national pilots; - Foster networking among implementing parties, Member Countries, and relevant stakeholders - Discuss the linkage of national pilots implementation to the MRC's Basin Development Plan.
2 (pilot implementation)	Organize National Consultative Forum in each country during the national pilot roll out (Q3)	- Facilitate Member Countries (Cambodia, Lao PDR, Thailand and Viet Nam) to convene national consultative forum in order discuss the national pilots to be implemented with concerned national stakeholders; - Introduce Member Countries, line agencies, and stakeholders to innovative technology solution for national pilot.

- *Mekong Institute (MI)* (Refer to Annex 6: MRCS PPT)
  As representatives from MI could not participate in the meeting, the Project Manager presented on behalf of Mr. Suriyan Vichitlekarn, Executive Director. MI participated in all project milestones in 2022 to design its upcoming capacity building from 2023 once the national pilots have kick started. Under Output 1, MI developed a study on "Sustainable Development in the Lower Mekong Basin: Building Forward Better toward COVID 19 Recovery with Water Energy Food (WEF) Nexus Approach through South-South and Triangular Cooperation". This study will be discussed and disseminated in the Second Regional Forum. To increase project visibility and network with likeminded stakeholders, MI introduced P-LINK at the Greater Mekong Subregion (GMS) Working Group Meeting and Lancang-Mekong Research and Policy Forum in 2022.

  In 2023, MI will carry out two capacity building workshops. The first one will be face-to-face, and the latter will be in an online follow-up training workshop. It will be arranged as a training of trainer (ToT) with 2~3 participants from four partner countries. The training will focus on national pilot design and indicators as well as identified common intervention topic for discussion. This could be extracted from this year's Regional Stakeholders Consultative Forum. MI will work closely with MRCS and STEPI to design the training curriculum as well to convene the workshops and monitor the learning curve of the trainees.

Agenda Items 3 & 4: Summary of Discussion Outcomes Pertaining to Issues for Steering Committee Decision

Before proceeding to in-depth discussion on issues that require Steering Committee decision, Ms. Ines Tofalo, Trust Fund and Programme Management Specialist at UNOSSC delivered a presentation on South-South Trust Funds (Refer to Annex 7: UNOSSC PPT). Ms. Tofalo emphasized that her presentation explains where P-LINK will be anchored within the new institutional arrangement of UNOSSC. She introduced four South-South Trust Funds managed by UNOSSC namely, *India-UN Development Fund*, *India-Brazil-South Africa (IBSA) Facility*, *UN Fund for South-South Cooperation (UNFSSC)* and *Perez-Guerrero Trust Fund for South-South Cooperation (PGTF)*. These Trust Funds are comprised of diverse project portfolios and background both in terms of financial scale and implementation modality. She highlighted that the RoK-UNOSSC Facility funds are channeled through UNFSSC, where the project will be located. In fact, the RoK it is the second largest contributor for UNFSSC after China. Projects under UNFSSC are directly implemented by UNOSSC. So, the level of attention and commitment is significantly higher at project level than for projects for which UNOSSC solely serves as Fund Manager and Secretariat of the Board. For instance, Chinese projects have Project Teams based in Beijing and New York as they directly support project implementation. Once P-LINK is located under UNOSSC's Trust Funds, the project could build synergies with other projects, notably to facilitate coordination and enhance project visibility.

Table 5 summarizes major issues discussed and the decision made by the Steering Committee in moving forward.

Table 5: Key Issues discussed and Steering Committee's Decision

Item	Main discussion issue	Decision
1	Integrate the proposed MSP modality with the Regional Stakeholder Forum	Endorsed by the SC, which concurred that additional resources would otherwise be required to fully operationalise such platform.
2	Finetune results framework (indicators)	Suggestions: - Include indicators to reflect the linkage between local pilots and regional policy framework. - Develop/select indicators at two levels: 1) general indicators to measure output delivery/impact on the regional development; and 2) specific indicators to measure the progress and impact of the national pilots.

		- STEPI could get advisory services from an expert in Mekong development project to develop/select general set of indicators aligned with BDS 2020-2030.
3	Request for a postponement of the mid-term evaluation	Endorsed to complete by 2024 Q1 as the SC recognized that setting up the mid-term evaluation timeline clearly also helps the Project Team to better manage timelines and milestones delivery. Therefore, the project should have very concrete results to demonstrate by its midterm review, which will allow for a meaningful assessment and advice for moving forward.
4	Proposed new Project Management structure	Endorsed, whilerequesting for high-level of attention to P-LINK.
5	Proposed new Steering Committee structure	The SC recommended that the proposed new SC structure to be considered for an interim period. Once UNOSSC Director is on board in March, the original arrangement could be continued as requested by MSIT.
6	Endorsement of 2023 work plan	Endorsed with request from SC to expedite the implementation process to deliver in line with the project timeline. The Project Management Team explained resources are allocated according to the resources that have been received, and in line with the Letters of Agreement (LoA) between each individual institution and UNOSSC. The Project Management to revise LoAs once more resources have been allocated by MSIT.
7	Next SC meeting arrangements	To convene the next meeting after the mid-term evaluation (2024 Q1- TBC). It could be arranged in a hybrid format. The meeting could consider alternative locations other than Seoul.

Agenda Item 5: Any other items

- Strategizing exit plans to scale up the national pilots by exploring possibility to link with other funding sources such as the Global Environment Facility (GEF)/Global Climate Fund(GCF)
  - The SC members concurred that the exit plans should always be thought from project design and throughout implementation as the project has great potential for sustainability and scale-up to link up with bigger initiatives and non-state actors such as the private sector.
  - The Chair requested the SC members and the Project Team to propose any suggestions that could be presented as an important task for the Project Management Team to build into the mid-term evaluation.

Closing Remarks

The Chair stressed that the meeting had been an important exercise for the Project Team to review the project progress, revisit challenges and issues, and offer recommendations on the way forward, especially on the national pilots, facilitating regional dialogue on integrated approaches to management of water, energy and food, as well as proposed project management structure. She further acknowledged the groundwork undertaken. She reiterated the urgency to sharpen project results framework and indicators. She congratulated the SC for successfully reaching decisions on items on the agenda, which will enable the project to move forward with a common understanding among implementing institutions.

Ms. Jang, the co-chair appreciated the value of the SC meeting in reviewing the progress made to jointly plan for upcoming activities. She expressed her willingness to work together and support all implementing institutions. Ms.

Jang stated the resolute stance of the Government of Korea that stands ready to help address WEF nexus issues in the four LMB countries, namely Cambodia, Lao PDR, Thailand and Viet Nam.

Signed by:

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Xiaojun Grace Wang
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28-Feb-2023

Ms. Xiaojun Grace Wang
UNOSSC – Officer-in-Charge
Interim Chair of the Steering Committee

Annex 3

Prepared by MRCS and UNOSSC
19 September 2023

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

SECOND REGIONAL STAKEHOLDER CONSULATIVE FORUM

FINAL SUMMARY REPORT

Thursday, 31 August 2023 (Hybrid)
Marriott Marquis Bangkok Queens Park Hotel, Bangkok, Thailand

I. Introduction

The MRC Secretariat and the United Nations Office for South-South Cooperation (UNOSSC) on August 31 jointly convened the Second Regional Stakeholder Consultative Forum under the project entitled, "Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus" also known as the RoK-UNOSSC Facility Phase 3/P-LINK. More than 40 delegates from the four MRC Member Countries – Cambodia, Lao PDR, Thailand and Viet Nam - joined the meeting in person. The participants included representatives from the National Mekong Committee Secretariats, line ministries responsible for water, energy, and food management and identified pilot site community stakeholders. Representatives from the Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) attended the event in their capacity as implementing parties under the P-LINK.

The forum was opened by Dr. Anoulak Kittikhoun, CEO of the MRC Secretariat, and Ms. Dima Al-Khatib, Director of UNOSSC. The forum consisted of four (4) sessions, of which the first provided latest project progress, refined results framework and pilot site indicators. As the forum highlight, country delegations presented the development challenges related to access to water, energy and food in the identified national pilot sites during the second session. They also indicated national and local stakeholder engagement arrangement and relevant national and sub-regional development frameworks that the pilot would contribute to in the long run. Followed by country presentations, STEPI provided technical solutions to be introduced in the identified site. The forum also served as a platform for countries to share their pilot design and dive into finetuning technical arrangements including national approval process before official roll-out in 2023 Q4. The third session focused on learning about other similar WEF nexus related projects based on the case studies conducted by STEPI and MI. In the last session, MI provided an overview of the capacity building modality that will facilitate national pilot implementation in the four countries. The Forum concluded with concrete follow-up actions in formalizing the national pilot project information note for approval and charting out technical tasks before official launch of pilots.

II. Objectives

The Stakeholder Forums are envisaged in the project document as a mechanism to ensure full participation of the MRC Member Countries, and to promote ownership and leadership in line with South-South and triangular cooperation (SS & TrC) approaches. The second forum was intended to (1) Update project progress and work plan by the Project Team (2) Provide an opportunity for the MRC Member Countries and the Project Team to present on the proposed national pilot design, approach, engaged stakeholders, linkage to the Basin Development Strategy, and guidance on next steps for implementation (3) Present and discuss knowledge products conducted by STEPI and MI on other WEF Nexus initiatives in the regional and beyond to draw key implications applicable to P-LINK, (4) Provide background on capacity building modality for national pilot implementation, (5) Foster networking among Member Countries, implementing parties, and relevant stakeholders.

Since the First Regional Stakeholder Forum in June 2022, the Project Management Team consulted with National Mekong Committees and undertook field visit to identified pilot site to better understand the local context. Technical visit to Thailand's site will be arrange in mid-October.

III. Proceedings of the Forum

As the main convenor of the event and the implementing party responsible for the consultative process, MRC Secretariat facilitated the meeting proceedings. Dr. Nittana Southiseng, Monitoring and Evaluation Specialist moderated the opening session.

In his remarks, Dr. Anoulak Kittikhoun, Chief Executive Officer of the MRCS addressed the progress made by P-LINK in the MRC Member Countries. The progress has involved consultations, reviews, site visits, and studies of national pilot sites to determine the most suitable projects and innovative technology solutions to address water-food-energy nexus issues in Member Countries (Cambodia, Lao PDR, Thailand and Viet Nam). Some have made progress in project concept development, and some still require further finetuning, site visits and consultations. Despite this, Dr. Kittikhoun emphasized the importance of selecting the right country-driven project and technology for solutions and making a difference on the ground and broader impacts in the Mekong countries and the region. He concluded by expressing appreciation for the Member Countries' participation and commitment, as well as the UNOSSC, STEPI, and Mekong Institute for their strong collaboration and continued support throughout the project implementation period.

Ms. Dima Al-Khatib, UNOSSC Director underscored the importance of operationalizing the technical customized solutions based on the WEF Nexus to improve the livelihoods of the targeted communities. To ensure sustainability of the solutions as well as their scalability within the respective national contexts, she requested MRC Member Countries' active engagement and commitment to the project in guiding the Project Team. She wished that the eventual successful outcomes of this project will represent a model for other Global South countries. In parallel, the project will serve as a policy and networking platform for the four Member Countries to deepen their collaboration through policy dialogues and integrated management of shared resources based on the technical pilots.

Session 1: Project Update

The session included three presentations on the 1) forum objectives and agenda, 2) project progress update including its finetuned results framework and 3) specific indicators for national technical pilots.

Dr. Nittana Southiseng started the session by walking through the event agenda and explaining the forum objectives (Refer to Session 1 MRCS Presentation). In the second presentation, Ms. Yejin Kim, Project Manager, presented the milestone work achieved since the first regional stakeholder forum and remaining activities to be delivered in 2023 Q3 and Q4 as well as the finetuned results framework (Refer to Session 1 UNOSSC Presentations). She kindly requested greater ownership and accountability from the countries to expedite national pilot roll out this year. Echoing UNOSSC Director's message on pilot sustainability and scalability, she highlighted that successful national pilot implementation could allow opportunities to connect with other relevant development projects at the local, national and regional level and design new initiatives through the Green Climate Fund (GCF) and Global Environment Facility (GEF). Ms. So Hyun Kwon, Senior Researcher, Division of Global Innovation Strategy at the Science and Technology Policy Institute (STEPI) introduced the national pilot indicators that are aligned with the *MRC BDS 2021-2030* and the *Sustainable Development Goals (SDGs)* and explained the rationale on the design of these indicators (Refer to Session 1 STEPI Presentation).

Session 2: Presentations on National Pilots by Member Countries ***and Proposed Technical Solutions by STEPI and RoK Experts***

Severing as a match making platform, the second session comprised of presentations featuring the local demand (country led), and RoK technical solutions to alleviate identified local needs (STEPI proposals and reflections) followed by Q&A for the four countries. Pilot site identification had been consulted through a series of national consultations and field visits since September 2022. Prior to the event, STEPI had offered technical proposals to each country. This session included four sub-sessions dedicated to each country in the following alphabetical order: Cambodia, Lao PDR, Thailand and Viet Nam (Refer to Session 2 Presentations). Representatives from the National Mekong Committees[1] provided the local demographics in the identified pilot site and challenges as well as shared their expectations about the technology solutions and how pilot activities are aligned with their national development frameworks. They also briefed the meeting on the proposed pilot implementation arrangement at the national and local levels.

In response, Dr. Hwanil Park, Chief Director and Research Fellow, Division of Global Innovation Strategy, STEPI and Dr. Dongun Park, Associate Research Fellow, Office of SDGs Innovation Research shared their assessments and reflections of pilot sites and further explained the appropriate technologies to be applied in these areas and their expected social, environmental and economic benefits.

In this session, Mr. Santi Baran, Chief Strategy and Partnership Officer, facilitated discussions among Member Countries, STEPI, and Korean experts by providing more explanations about local situations and technology proposals for mutual understanding. He also suggested to the Korean team to finetune the proposal for more compatibility with the local context, considering sustainability, operation and maintenance costs, and scalability.

The Table below provides a summary of country presentations and matched solutions.

Table 1: Country Feedback and Next Steps

Country	**Project Title**	**Objectives**	**Proposed tech solutions**
Cambodia	Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng	• Improve clean water access using renewable energy • Improve agricultural productivity for food security	*Solar power generated water treatment system*
Lao PDR	**National Level:** A centralized data center and situation room at the national level for water management.	• To establish the centralized data center and situation room for effective management and coordination of water resources in Lao PDR	*Note: Lao PDR's presentation on national pilot project focused on both issues/demands at the national level (centralized data center and situation room) and*

[1] Presentations delivered by Cambodia (Mr. Chheang Hong), Lao PDR (Mr. Keomany Luanglith), Thailand (Mrs. Thayida S. van Corstanje) and Viet Nam (Mr. Nguyen Xuan Tung).

	Local Level: • Construction of irrigation canal including pumping station + electrical system installation • The rehabilitation of the existing irrigation scheme in the village • Improve rice seed varieties and training related to seed multiplication • Support planting vegetables in the shade for the marketing		*local level (construction of irrigation canal).* *STEPI proposed Local Flood Early Warning System (LFEWS) incorporating local knowledge and experience as well as a combination of relevant appropriate technical solutions. Lao PDR will further consult with local authorities on this.*
Thailand	Increasing the Efficiency of Tap Water System in Moo (Villages) 1, 2 and 3 Bung Khla Sub-district, Bueng Kan Province	• Increase access to clean water for household use, now and in the future • Decrease the cost of tap water production	*Note: As Thailand's site was decided right before the regional forum, the Project Team will undertake a site visit to assess the situation in mid-October and prepare pilot proposal accordingly.*
Viet Nam	Improvement of Livelihoods through the Application of WEF Nexus Approach in the Mekong Delta of Viet Nam	• Meet the high demand for freshwater use in local communities • Improve access to safe domestic water and improve local livelihoods	Saline groundwater desalination system generated by renewable energy (preferable solar)

Note: In addition to the proposed technical solutions, the project will also provide capacity building related to effective agriculture productivity and management.

Session 3: Integrated development approach through the WEF Nexus and the Presentation of knowledge products

The session opened with the video remarks of Ms. Xiaojun Grace Wang, Trust Fund Director of UNOSSC. Ms. Wang underlined the spirit of South-South and triangular cooperation (SS & TrC) facilitating the sharing of knowledge and experiences. As P-LINK tries to incorporate lessons learnt from other similar WEF Nexus projects for effective delivering while avoiding bottlenecks, she also wishes that the project could set a good example of an integrated work driven by nexus approach and SS & TrC that could be shared with other development stakeholders. Ms. Jeehye Min, Researcher, Division of Global Innovation Strategy, STEPI delivered a presentation on implications drawn from STEPI's analysis of three cases[2] at global and regional levels (Refer to Session 3 STEPI Presentation). STEPI's publication was disseminated to participants at the event. Mr. Suriyan Vichitlekarn, Executive Director of the Mekong Institute (MI) introduced key analysis of two Nexus projects[3] in the Lower Mekong Basin from SS & TrC and Build Forward Better aspects. Both STEPI and MI pointed out the multi-stakeholder cooperation, co-benefit creation and flexibility as vital success factor in a Nexus project. In addition to technical transfer, concerted

[2] WE4F (GIZ, EU, USAID, etc.)- global level, Urban Nexus (ESCAP-GIZ) and LAC (IDB and K-Water)
[3] WE4F – Southeast Asia level, Thai NAMA (GIZ)

efforts are required to foster policy awareness on integrated resource management and cross-regional are vital to scale-up local and country level work.

Member Countries' Group Discussion

Based on the presentations and discussions in the second session, countries took the ownership and accountability to strategize their national roll out plan and chart out specific action plans. The country discussions were guided by a list of items that required national decision-making namely, scope, implementation structure, budget (cost-sharing possibilities), monitoring and evaluation measures, and national approval process.

Following the group discussions, each country made a presentation on their action plan and follow-up actions required by the project team as shown in Table 2.

Table 2: Country Feedback and Next Steps

Country	**Country Feedback**	**Next Steps**
Cambodia	Some of the activities not within the P-LINK scope; Suggested adjusting main activities aligned project scope, as it is too diverse.	• Project timeline: Nov 23 to Dec 24 • Project team to submit the revised project information note including budget and implementation structure
Lao PDR	A need to clarify the process and timeframe for STEPI to understand and assist better.	• Lao delegation to conduct another field visit, consult provincial authorities on STEPI's proposed project, then inform STEPI on the outcome (Sept 23) • Project team to submit the revised project information note including budget and implementation structure
Thailand	Expressed interest to replicate the pilot in Bung Khla in other two sites with the country's resources.	• TNMCS and Project Team to conduct field visit to Moo (Villages) 1, 2 and 3 Bung Khla Sub-district ASAP to develop project information note. • Budget & detailed proposal to be discussed and finalized
Viet Nam	Noted that the practicality of the proposed solution but the details should be discussed further so that VNMC could inform Ben Tre provincial government and finalize the approval process both at national and local levels.	• Project timeline: TBC • Project team to submit the revised project information note including budget and implementation structure

Session 4: Overview of Capacity Building Modality for National Pilot Implementation (MI)

Ms. Jian Wang, Program Manager, Sustainable Energy and Environment Department at the Mekong Institute (MI) provided an overview of the capacity building modality under the Project. The training is designed into two tracks: regional Training of Trainers (ToT) and national training workshops. The regional ToT will be held face-to-face annually followed up by virtual national training workshops to help implement and monitor the national pilots. (Refer to Session 4 MI Presentation).

IV. Key Takeaways and follow-up actions

- Member Countries are to approve to the proposed projects by 2023 (i.e. through the letter to the MRCS). National pilots are to be rolled by 2023 Q4.

- The Project stakeholders should collectively work together to translate/re-orient the WEF nexus approach in the context of Mekong region and drawing on the lessons learnt from past projects in other localities.

- Countries demonstrated national ownership and accountability in design and implementation of pilots in the countries. The Project Team to expedite baseline data gathering[4] work to fine tune the project information note. The national project information note will include the core components of a brief project document, outlining implementing country level activities (to include and specific budget, timeline, implementing structure and M&E arrangements).[5] STEPI will help each country prepare a formal project proposal/note, where a template[6] will be made and provided to MCs to fill as part of the proposal.

- Field visits may be conducted as needed. For Thailand, the project team is to conduct a site visit to identified site to assess the local situation and finalize the pilot proposal.

- The forum facilitated the project's endeavour to develop one joint work plan as each country delegation indicated their national development priorities and proposed possible pilot sites in their respective countries. They however, indicated the need for further consultations with other stakeholder in their countries on the pilots and implementation structures. To that end, the Project Management Team will work with the other implementing parties (MI, MRCS and STEPI) to allocate resources and follow-up with each country bilaterally to organise national consultations towards rolling out national pilot sites.

[4] Baseline data collection: Based on available national and local data base (may request support from Member Countries) and STEPI will also hire local consultant for this work.
[5] Proposed Table of Content: 1) Introduction 2) Objectives 3)Budget/cost sharing 4)Duration 5) Project Implementation Structure 6) M&E and reporting arrangements
[6] The Project Team will prepare a template and seek inputs and review from Member Countries.

Annex 1: Meeting Agenda

TIME	ITEMS
9:00 – 9:30	Registration
9:30 – 9:45	**Opening Session** *Moderator: Dr. Nittana Southiseng, Monitoring and Evaluation Specialist* • Participants Introduction • Welcome Remarks – Dr. Anoulak Kittikhoun, CEO, MRCS • Opening Remarks – Ms. Dima Al-Khatib, Director, UNOSSC
9:45 – 10:00	Session 1: Project Update • Objectives and Agenda (MRCS) • Project progress update and finetuned project results framework (UNOSSC) • Overview of national pilot indicators (STEPI) to explain the rationale of selecting a set of relevant indicators to measure the impact of technical solutions in respective sites
10:00 – 10:30	Session 2.1: Presentations on National Pilots by Member Countries and Proposed Technical Solutions by STEPI and RoK Experts (Geographical background, local needs, engaged stakeholders, linkage to the BDS, technical solutions, guidance on next steps, etc.) • Cambodia (10mins) • STEPI/ROK Experts (10mins) • Discussions (10 mins)
10:30 – 10:45	Group Photo and Coffee Break
10:45 – 11:15	Session 2.2: Presentations on National Pilots by Member Countries and Proposed Technical Solutions by STEPI and RoK Experts (Geographical background, local needs, engaged stakeholders, linkage to the BDS, technical solutions, guidance on next steps, etc.) • Lao PDR (10mins) • STEPI/ROK Experts (10mins) • Discussions (10 mins)
11:15– 11:45	Session 2.3: Presentations on National Pilots by Member Countries and Proposed Technical Solutions by STEPI and RoK Experts (Geographical background, local needs, engaged stakeholders, linkage to the BDS, technical solutions, guidance on next steps, etc.) • Thailand (10mins) • STEPI/ROK Experts (10mins) • Discussions (10 mins)
11:45-12:15	Session 2.4: Presentations on National Pilots by Member Countries and Proposed Technical Solutions by STEPI and RoK Experts (Geographical background, local needs, engaged stakeholders, linkage to the BDS, technical solutions, guidance on next steps, etc.) • Viet Nam (10mins) • STEPI/ROK Experts (10mins) • Discussions (10 mins)
12:15 – 13:30	Lunch
13:30 – 15:00	**Session 3: Integrated development approach through the WEF Nexus and the Presentation of knowledge products** • Video message, Ms. Xiaojun Grace Wang, Trust Fund Director, UNOSSC (3 mins) • Presentation of the Knowledge Products by STEPI (10 mins) • Presentation of the Knowledge Products by MI (10 mins) • Discussions/Q&A (7 mins)

14:00-15:15	**Member Countries' Group Discussion** • Guidance on national approval process • Proposed/national local implementation structure • Budget allocation/cost sharing • Monitoring & reporting • Timeline
15:00 – 15:15	Coffee Break
15:15 – 16:30	• Presentations of the results from the discussion • Q&A
16:15 – 16:45	**Session 4: Overview of Capacity Building Modality for National Pilot Implementation (MI)** • Presentation by MI (15 mins) • Discussions/Q&A (10 mins)
16:40 – 17:00	**Closing Session (Summary and Way Forward)** *– UNOSSC and MRCS*

Annex 2: List of Participants

National Mekong Committees (NMCs)

Delegates from Cambodia

1.	H.E. Mr. Sok Khom	Deputy Secretary General, CNMC[7]
2.	Mr. Chheang Hong	Director of Information and Knowledge Management Department, CNMC
3.	Mr. Touch Bunthang	Deputy Director of Inland Fisheries Research and Development Institute, Fisheries Administration, MAFF[8]
4.	Mr. Pen Raksa	Vice Chief office, Department of Water Supply and Sanitation, MoWRAM[9]
5.	Mr. Ou Sophanna	National Coordinator for AD[10]/OCEO[11], CNMC

Delegates from Lao PDR

1.	Mr. Phonepaseuth Phouliphanh	Secretary General, LNMCS[12]
2.	Mr. Keomany Luanglith	Director of Division; AD/OCEO National Focal Point
3.	Mr. Laty Souliyadeth	Officer, Livelihood Restoration Project for People Affected from Nam Theun 2 Hydropower Project, Khammuan Province
4.	Mr. Sisavath Kertkong	Director of Division, Ministry of Agriculture and Forestry
5.	Mr. Somphone Khamphanh	Deputy Director of Division; TD[13] National Focal Point
6.	Ms. Latsamy Banmanivong	Assistant to AD/OCEO National Focal Point,

Delegates from Thailand

1.	Mr. Chumlarp Tejasen	Director of Foreign Affairs Division, ONWR[14]
2.	Mrs. Thayida S. van Corstanje	National Coordinator for AD&OCEO
3.	Ms. Warangkana Larbkich	National Coordinator for ED[15]
4.	Ms. Nantawan Suwansatit	Director, Environmental Assessment Sub-division
5.	Mr. Naruepon Sukumasavin	Advisor to TNMCS[16]
6.	Ms. Phatchara Amphawanon	Foreign Relations Officer, Senior Professional
7.	Ms. Panisa Semsan	Foreign Relations, Practitioner
8.	Mr. Ittikorn Buasomboon	Environmentalist practitioner level
9.	Mr. Naris Arthan	Coordinator of Terd Duay Dham Water User Organization

[7] Cambodia National Mekong Committee
[8] Ministry of Agriculture, Forestry and Fisheries
[9] Ministry of Water Resources and Meteorology
[10] Administration Division
[11] Office of the CEO
[12] Lao National Mekong Committee Secretariat
[13] Technical Support Division
[14] Office of the National Water Resources
[15] Environmental Management Division
[16] Thailand National Mekong Committee Secretariat

Delegates from Viet Nam

1.	Dr. Truong Hong Tien	Deputy Director General, VNMC[17]
2.	Mr. Nguyen Xuan Tung	Official, VNMC
3.	Mr. Nguyen Duc Hoang	Official, VNMC
4.	Mr. Nguyen Trung Quan	Official, VNMC
5.	Mr. Nguyen Thi Tho	Official, MONRE[18]

Mekong River Commission Secretariat

1.	Dr. Anoulak Kittikhoun	Chief Executive Officer
2.	Mr. Phetsamone Khanophet	Director of Environmental Management Division
3.	Mr. Santi Baran	Chief Strategy and Partnership Officer
4.	Dr. Nittana Southiseng	Monitoring and Evaluation Specialist
5.	Mr. Sopheak Meas	Stakeholder Engagement Specialist
6.	Ms. Aphasone Dejvilayphone	Administrative Assistant
7.	Mr. Bounyong Phounpaseuth	IT Assistant
8.	Mr. Thanawat Wetchapan	Strategy and Partnership Project Assistant

UN Office for South South Cooperation

1.	Ms. Dima Al-Khatib	UNOSSC Director
2.	Ms. Yejin Kim	Project Manager

Science and Technology Policy Institute

1.	Dr. Hwanil Park	Chief Director and Research Fellow, Division of Global Innovation Strategy
2.	Dr. Dongun Park	Associate Research Fellow, Office of SDGs Innovation Research
3.	Ms. So Hyun Kwon	Senior Researcher, Division of Global Innovation Strategy
4.	Ms. Jeehye Min	Researcher, Division of Global Innovation Strategy

RoK experts (On-Site)

1.	Dr. YoungJoo Lee	Principal Researcher, K-Water

RoK experts (Online)

1.	Dr. Yongcheol Kim	Principal Researcher, KIGAM(Korea Institute of Geoscience and Mineral Resources)
2.	Dr. Eugene Kim	Director, MAGPIE SOFT

Mekong Institute

1.	Mr. Suriyan Vichitlekarn	Executive Director
2.	Ms. Jian Wang	Program Manager, Sustainable Energy and Environment Department

[17] Viet Nam National Mekong Committee
[18] Ministry of Natural Resources and Environment

Annex 3: Group Photo

P-LINK
People's Livelihoods Initiative through water-energy-food Nexus in the MEKONG Region

STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus: RoK-UNOSSC Facility Phase 3/P-LINK

Proposal on Technology Solution for Cambodia

1. Introduction

The P-LINK, a project entitled "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. It takes integrative and multi-sectoral approaches in application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea, and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI), and will enlist the support of other UN Agencies.

In the third year of the P-LINK, UNOSSC, STEPI, and three National Mekong Committees agreed on pilot sites and applied technology solutions in Cambodia, Lao PDR, and Viet Nam and are expected to carry out a pilot implementation accordingly. Against this background, STEPI has prepared a proposal on a technology solution for each country.

The main objective of this proposal is to provide a general introduction to a technology solution for the selected pilot site in Cambodia. In this regard, the proposal first outlines the pilot site and its challenges. It then presents the basic concept and its main components, a review of available technologies for each component, and proposed candidate technologies. Lastly, it concludes with the expected benefits of the technology solution.

2. Local Challenges and constraint

Based on the observations from the field visit and desk analysis, the CNMC and STEPI agreed on Sdao Community, Sesan District, Stung Treng Province as a suitable site for the subsequent pilot implementation. The site met three key criteria: 1) conformity with the objectives and directions of the P-LINK, 2) suitability to the WEF Nexus approach, and 3) impact of the project on the social, environmental, and economic aspects.

The Sdao Community has been suffering from diverse Water-Food-Energy Nexus challenges as shown in Table 1. In this regard, the following possible solution is recommended as one of the possible solutions to mitigate the local challenges faced by the Sdao community:

Clean water supply system equipped with renewable energy source to provide more affordable and sanitary water.

Purify water from groundwater aquifer or river
System to supply electricity from renewable energy source.

Table 1. Analysis on the proposed pilot site

Site	Sdao Community, Sesan District, Stung Treng Province
Location	
Main challenges	Main challenge to tackle is to minimize clean drinking water stress and to ensure sustainable energy supply.
Suitability to the WEF Nexus approach	**WATER: limited access to the safe drinking water** The Sdao community installed a water supply facility with water pump with the support of a local NGO ("My Village) in 2019 to utilize ground water (refer to Photo 1). However, only 80 households have regular access to this facility and the rest of the households have limited access to this water supply facility because they cannot afford the water tariff (1 USD for $4m^3$). Many households use individual electric pumps or bring water manually from the nearby river. The major issues of Sdao Community are limited access to the existing water supply facility and thus many households are suffering to secure household water supply. Furthermore, there are potential health hazard caused by the untreated drinking water. **ENERGY: Limited access** There is electric power grid provided by the provincial government. But, many households cannot afford the energy cost and rely on biofuels. Yet, with deforestation, it is hard to finds wood for such purposes. Community members have to travel further away from their neighborhoods to collect wood. **FOOD: Limited irrigation for rice field** The community members requested for technical expertise to diversify crops that can be cultivated in two different seasons (wet and dry) in their locality. With changes in climate, rice paddy fields get extremely dry, resulting in

decreased agricultural productivity. There are situations when they do not yield any crops and lack sufficient food resources, which not only affects their wellbeing of community members but also their income.

Photo 1: Installed water tank facility in the community

Photo 2: Rice cultivation area

Climate Change: Extreme weather conditions

The community has been exposed with more frequent flash floods that affect their livelihood. There have been cases the riverbanks destroyed from heavy rain. In the dry season, the locality faces drought from August to September that affects their agricultural productivity. The community find it difficult to monitor the weather conditions and wish if there is any appropriate technology that can facilitate them to regularly check the water level and climate conditions.

Source: STEPI (2023) P-LINK site selection summary report

3. Technology Review

3.1 Water Supply System

In order to plan and design a self-sufficient water supply system at a small village level, several aspects need to be considered, such as treatment facility capacity, water sources, and treatment processes. Here are some general considerations:

(i) Ensuring safe drinking water: The quality of the supplied water should always meet appropriate standards, regardless of the situation, and there should be a consistent and sufficient water supply.

(ii) Construction and maintenance: The construction and maintenance should consider the capabilities of local experts or water utilities. It is essential to assess the capacity of the water management agencies or local authorities in Cambodia before establishing the water infrastructure.

(iii) Infrastructure: The infrastructure should be built with minimal facilities, utilizing the available resources in the area to create a robust and reliable system. In small-scale service areas, it is necessary to minimize the use of labor-intensive equipment such as the coagulation process and operation of pumps.

(iv) Monitoring the performance of the water treatment facilities: It is crucial to install a suitable monitoring system to assess the performance of the treatment facilities. Additionally, contingency equipment should be secured to prepare for unexpected changes in raw water quality or equipment failures. All these plans should be developed collaboratively, considering the technical knowledge and capabilities within the target area while also meeting the demands and preferences of the community.

In Cambodia, the Ministry of Industry, Science, Technology, and Innovation (Misti) manages the development policies and regulations for water supply facilities. The table below presents the drinking water quality standards for critical parameters in Cambodia.

Table 1. Water quality standards for drinking water in Cambodia

Parameters	Unit	Cambodia	Korea	WHO
pH		6.5 ~ 8.5	5.8 ~ 8.5	
Turbidity	NTU	5	0.5	≤ 5
EC	µS/cm	1,500		250
Hardness	mg/L	300	300	
Arsenic (As)	mg/L	0.05	0.01	0.01
Manganese	mg/L	0.1	0.05	
Ammonia / Ammonium	mg/L	1.0	0.5	
Nitrate (NO_3^-)	mg/L	50	10	50
Nitrite (NO_2^-)	mg/L	3	-	3
Escherichia coli (E. coli)	cfu/100mL	0	0	
Total coliforms	cfu/100mL	0	0	

Iron (Fe)	mg/L	0.3	0.3	
Chloride (Cl)	mg/L	250	250	
Phosphate (PO_4)	mg/L	N/A		
Sulfate (SO_4)	mg/L	250	200	
Sodium (Na)	mg/L	200		
Fluoride (F)	mg/L	1.5	1.5	1.5

* Source: Ministry of Industry Mines and Energy, Kingdom of Cambodia

3.2 Capacity of Water Purification Facility

In order to determine the capacity of the water purification facility, it is important to make accurate predictions of the per capita daily water consumption by conducting surveys on water usage for drinking and domestic purposes, considering the residents' lifestyles. However, at present, it is challenging to conduct a precise analysis in this regard.

Referring to the feasibility study report prepared by K-water for the Official Development Assistance (ODA) project in Cambodia, it is predicted that water consumption will gradually increase from 58 liters per capita per day (lpcd). Therefore, for this project, assuming a per capita daily water usage of 60 liters and considering the potential for population growth, the facility capacity is estimated based on a population of 2,000 requiring a water treatment facility with 120 cubic meters per day capacity.

However, it is important to verify the residents' preferences regarding the usage plan after establishing a pilot facility in the project area, as the assumed water consumption figures are based on considering water usage for domestic purposes through the supply pipeline. If the residents receive water directly and transfer it to their homes the actual demand may be lower. The estimated capacity based on the above figures would likely be sufficient in such a case.

3.3 Selection of Water Resources

Generally, except for coastal areas, selecting water sources involves assessment of the availability and suitability of surface water or groundwater from nearby rivers or dams, considering both quantity and quality throughout the year. Additionally, coordination with relevant agencies is necessary for the utilization plans of these water sources.

In the Sdao Community area, viable water sources are (i) surface water from the nearby Tonle Kong River, (ii) groundwater through well installations near the riverbanks. It is assessed that the Tonle Kong River can provide sufficient water quantities required for the treatment facility. However, due to climatic variations such as dry and wet seasons, careful consideration is needed for water quality fluctuations during the planning of treatment processes. Installing water intake facilities is necessary to ensure stable access to high-quality water.

The surface water with high concentration of particulate matter needs the application of coagulation-sedimentation-filtration process may be required, which requires a trained operator and thus may not be suitable for a small-scale community facility. Additionally, it is necessary to investigate pollution sources of upstream of the intake point for future water quality predictions.

As an indirect water intake method, groundwater well or infiltration gallery can be considered for water sources by installing a perforated pipe to directly intake water from a river, or infiltration gallery which substitute the upper layer of the perforated pipe with approximately 5 meters of sand to reduce particulate matter. In general, for the small-scale water supply facilities in rural areas, the indirect water intake methods have been employed to simplify subsequent treatment processes and ensure operational and management convenience. However, it is necessary to evaluate the water intake quantities considering the reduced flow rates due to sediment accumulation and fluctuations in groundwater levels.

For more concrete water supply plan, the assessment of current water supply and use of the Sdao community is essential to select applicable water treatment process. The analysis of raw water quality is crucial to select the intake method and treatment process.

In the case of river water, various pollutants such as particulate matter, synthetic organic matter, taste and odor substances and algae are treated, while groundwater is subject to pollutants according to the local geological and geographical characteristics. Microbes and turbidity are the main targets of treatment in groundwater; while, in the case of the Tonle Kong river water, turbidity, organic matter and unpleasant (in terms of taste and odor) substances are the main treatment target substances.

Table 2. Main target substances in water purification process

Items	Main controlled(target) substances
River (Tonle Kong)	- Turbidity (Particulate matter), microorganisms (E. coli. etc) - Algae and by-product (Taste and odorous materials (2-MIB, Geosmin) - Synthetic organic matter (Pesticides etc.)
Underground water	- Microorganisms and Organic materials - Turbidity - Arsenic, Nitrate and nitrite

Based on the water quality standards in the Republic of Korea and Cambodia, the following criteria have been set for the above substances to be treated, and the water treatment process would be designed and operated based on the following criteria.

Generally, water purification processes, including advanced treatments, have a different structure according to the quality of the water source. Different water treatment unit processes are applied depending on the type of target materials, as shown below.

Table 3. Applicable unit process according to target material in water treatment

Category	Items	Substance	Unit process
Parti- culate	Turbidity		Slow Filtration, Rapid Filtration, Membrane Filtration
	Algae		Membrane Filtration, Strainer, DAF
	Microorganism	Cryptosporidium	Slow Filtration Rapid Filtration, Membrane Filtration, O_3
		Bacterium	Chlorination, O_3
Soluble	Taste & Odor	Geosmin, 2-MIB	GAC/PAC, O_3(AOP)
	Disinfection byproduct	THMs Precursor	Slow Filtration Rapid Filtration, Membrane Filtration, O_3. GAC/PAC
	Surfactant		GAC, O_3(AOP), Biological
	Volatile Organic		GAC, Aeration
	Pesticide		GAC, O_3(AOP)

	Minerals	Fe	Oxidation (Cl, Aeration), Aeration & Filtration
		Mn	Oxidation (Cl,, O_3, Potassium Permanganate)
		Ammonia Nitrogen	Cl, Biological, Membrane Filtration (RO)
		Nitric Nitrogen	Ion Exchanger, Membrane Filtration (RO), Electrodialysis, Biological
		Fluorine	Coagulation, Activated Alumina, Membrane Filtration (RO), Electrodialysis
		Hardness	Softening, Membrane Filtration (RO), Ion Exchanger
		Aggressive Free Carbon Dioxide	Aeration, Alkali, O_3

Both surface water and groundwater sources can be used for the water supply of the Sdao Community area. It is necessary to analysis on the groundwater and surface water quality for the proper selection of water source and treatment process. The water quality analysis can be carried out at the laboratory (ILCC) of the Ministry of Industry, Science, Technology, and Innovation laboratory in Phnom Penh or private analysis institutions such as RDI.

3.4 Selection of Water Treatment Process

The conventional WTP (Water Treatment Plant) is composed of:

(i) Rapid mixing/coagulating tank: to mix raw water with chemical substance (alum). It is first step for removing solid particle for better turbidity.

(ii) Slow mixing/flocculation tank: to form the flocs by slowly decreasing the velocity of water. It is second step for removing solid particles for better turbidity.

(iii) Sedimentation tank: It is third step to let flocs and solid particles settle down by laminar flow.

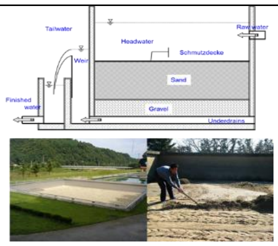
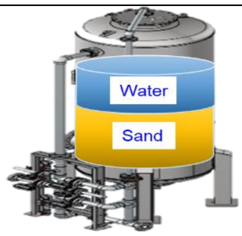
(iv) Rapid sand filtration (gravity filter): to remove the remaining suspended solid by layer of sand.

(v) Disinfection tank: the final stage of treatment is to remove the virus in the filtered water by chlorine injection. The presence of this substance in water (0.1-1.0 mg/L), it means that this treated water is safe to consume.

If there are no specific contaminants in the particulate matter to be removed, the water treatment process consists of pre-treatment, filtration, and disinfection processes. The treatment plant design is to remove particulate matter (turbidity), and bacteria (e. coli and coliforms). Conventional design is easy for local people to operate, and material of construction could be found locally. Based on the result of water quality testing, proposed treatment processes are for mitigating turbidity and disinfection.

Based on the selection of water sources and the results of raw water quality assessment, if particulate matter, indicated by turbidity levels measured (Nephelometric Turbidity Units, NTU), is the main target for removal, the filtration method can be determined as follows.

Table 4. The filtration method by turbidity levels (NTU)

Raw Water Turbidity		
< 5 NTU	5 NTU < < 10 NTU	> 10 NTU
Direct Filtration, Slow Sand Filtration	Slow Sand Filtration, Membrane filtration	Rapid filtration, Membrane filtration
		
Slow sand filtration	Direct or rapid filtration	Membrane filtration

When establishing a water treatment system based on the raw water quality conditions above, the operation and maintenance cost varies depending on the use of coagulants.

Suppose a high-quality water source with a turbidity level of around 5 NTU is available through groundwater or indirect water intake. In that case, a simple filtration method, such as direct or slow sand filtration, can be employed. This allows for the effective removal of particulate matter and enables continuous utilization by implementing filter management practices such as removing filter media during intake or conducting backwashing at the treatment facility.

On the other hand, when using river water as the raw water source, which is prone to turbidity fluctuations, it becomes necessary to adopt a rapid filtration process involving coagulation, flocculation, and sedimentation. In such cases, operators play a crucial role in the continuous operation and maintenance of the water treatment facility, including chemical dosing, filter cleaning, and floc disposal. Therefore, the availability of skilled operators becomes essential, particularly when dealing with water sources of poorer quality.

The choice of a water treatment system can significantly impact the required footprint of the treatment facility. A simpler system can be installed within a smaller area if a high-quality water source is utilized. However, when faced with lower-quality water, including pre-treatment facilities increases the required space.

To treat the turbidity-causing particulate matter in river surface water, the implementation of standard water treatment processes becomes necessary, involving the use of coagulants and disinfectants as water treatment chemicals. It is vital to investigate the local availability of these chemicals for procurement and usage. In cases where obtaining and utilizing water treatment chemicals pose logistical or economic challenges, the treatment process design should minimize reliance on coagulants or consider alternative approaches.

Under such circumstances, utilizing high-quality groundwater as the primary water source is considered as an optimal solution, as it eliminates the need for water treatment chemicals.

3.5 Energy Source for Water Treatment System

In situations where groundwater utilization is inefficient, either due to quantity or quality concerns, the use of river water can be an alternative option. The solar energy can elevate the raw water to higher locations and then membrane filtration systems can be operated by the gravity energy. Although adopting specific membrane filtration modules may cause financial considerations, it offers the advantage of producing high-quality water without relying on traditional energy sources. The local accessibility of water treatment chemicals is a critical factor in determining the water treatment processes for the sustainable operation and maintenance of the facility. A thorough investigation is essential before finalizing the treatment process.

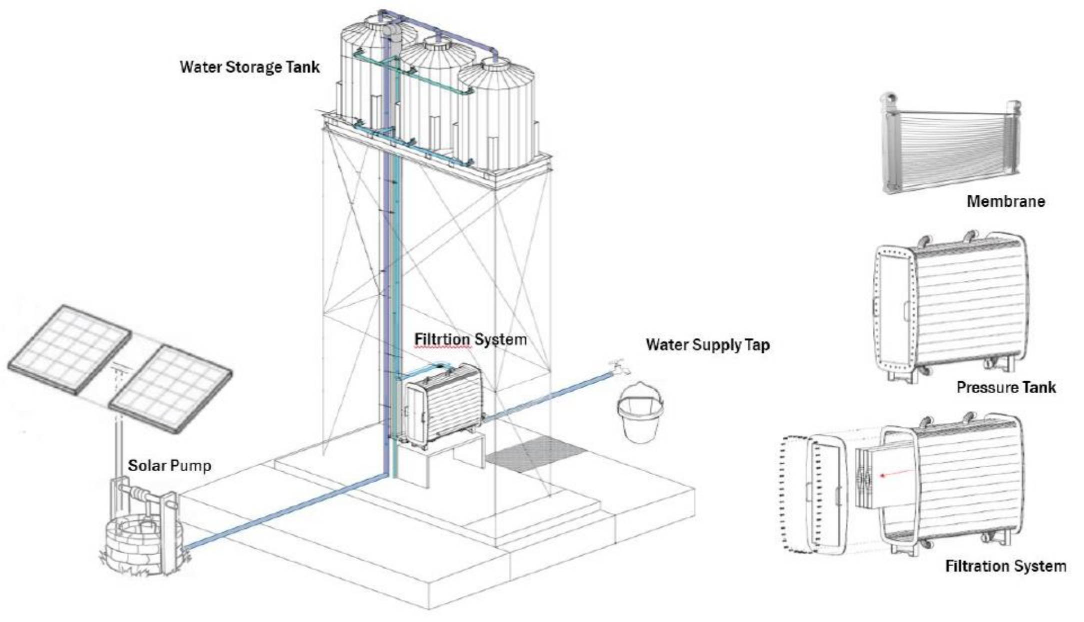


Figure 1. Case of Powerless water treatment system by KOLON. Co., Ltd. in Haiti

Suppose the water intake and treatment facilities cannot be located in the same place. In that case, it requires the establishment of pumps and pipelines to transport the raw water to the water treatment facility. The scope of project excludes the supply pipelines for distributing the treated water to individual households, which can reduce the economic burden by saving on the power costs for water distribution.

Therefore, it is necessary to consider evaluating renewable energy utilization systems, such as operating pumps through solar power generation or installing solar pumps. In other words, it is highly beneficial to introduce a water treatment system that utilizes the water head at a higher elevation reservoir facility, where the raw water is transported using solar power generated during the daytime.

4. Proposed technology solution: Water treatment system

In this project, the available water supply technology has been investigated in terms of the quality of raw water quality, intake method and water treatment process with energy sources reflecting the current situation of Sdao community, Cambodia. The solar powered water treatment facilities will achieve energy efficiency and promote sustainable development in this area.

For the water intake facility, two options are being considered: direct intake from rivers (Opt. 1) and indirect intake through the installation of infiltration gallery (Opt. 2). It is also possible to combine these two methods and utilize them appropriately based on the characteristics of the water source.

Considering there is no available water quality data for the applicable water source, the initial plan for the water treatment facility is to employ conventional water treatment, which involves removing particulate matter and disinfecting the water. However, for the indirect intake method using groundwater, a direct filtration approach without the need for pre-treatment is being considered. For the direct intake method from rivers, it is possible to install a pre-treatment process, such as solid-liquid separation, to adequately treat the particulate matter in the raw water before proceeding with filtration process.

Solar power generation during the daytime will supply the power required for water intake and treatment, which will transport water to a high-elevation reservoir and operate the water treatment process using gravitational potential energy.

The diagram below illustrates the conceptual design of a pilot-scale water treatment plant that integrates energy production technologies. For the implementation of pilot project, on-site investigations are needed to determine the specifications of the appropriate facilities, such as the elevation of each facility's installation location and the distance between them. For the water intake facility, data collection and research are required to select the water source, including river infiltration water and groundwater, as depicted in the diagram.

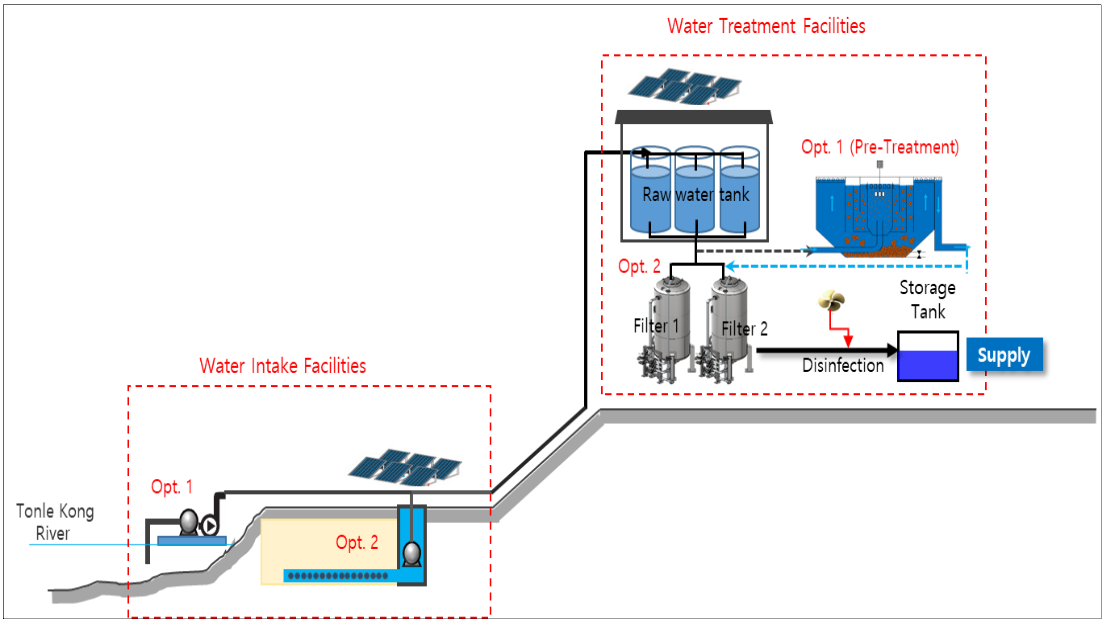


Figure 2. Concept Diagram of Pilot Scale - Water Supply System

For water treatment facilities, it is necessary to select a treatment process according to the need for pretreatment in connection with the selection of a water source. Considering the difficulties in purchasing water treatment chemical and the lack of expertise in operation in rural areas, the Option 2 is more viable water treatment process, which employs an indirect intake method.

The energy efficiency of solar power generation has been continuously improved, and installation costs have become more affordable. Therefore, it is necessary to install solar power generation facility with sufficient capacity on available sites with energy storage systems, and establish various interconnected facilities within the region, such as CCTV for security and nighttime lighting.

The operational system of the facilities should be designed to enable automatic operation as much as possible, using a level gauge installed in the tank where the final treated water is stored. When the water level reaches a certain threshold, the system operation is suspended, and when the water level decreases, the water treatment system is activated again. However, considering the decrease in filtration rate due to filter clogging during continuous operation, it is desirable to incorporate a differential pressure gauge system that indicates the time for backwashing.

5. Expected benefits

Safe water and hygiene are crucial elements of the Sustainable Development Goals (SDGs). In Korea's Country Partnership Strategy (CPS) for its priority partner countries, including Cambodia, water management is included, and the approach to expanding rural sanitation facilities shares similarities with the Korea International Cooperation Agency's (KOICA) approach.

The planned pilot facility construction for integrated water-energy production and supply for domestic use in the Sdao Community area of Cambodia can provide the benefits of supplying clean domestic water, which is essential for human life, through the establishment and operation of water treatment facilities. Constructing appropriate water treatment facilities in the Sdao Community area, where securing clean domestic water is currently challenging, is highly appropriate and efficient. It can help reduce the potential for waterborne diseases and provide the community with a safe domestic water supply.

As a result, local residents can lead healthier lives and increase their livelihood productivity. Protecting vulnerable groups such as infants, adolescents, and pregnant women from waterborne diseases can bring vitality to the local community and promote a healthy life.

The solar power generation facilities that are integrated to ensure sustainable operation of the treatment facilities can contribute to improving the quality of life in the local community in various ways, along with the stable operation of the water treatment facilities. Utilizing the space as a venue for activities such as music or film screenings, which enhance the prosperous life of the local community.

To make this project more efficient and sustainable, continuous support and interest from the local government are needed. Efforts from the beneficiary villagers, including understanding and efforts for clean water source management, are also required. Therefore, for the successful implementation of this project, it is also necessary to establish and communicate with local governance, including facility management companies.

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P-LINK
People's Livelihoods Initiative through water-energy-food Nexus in the MEKONG Region

STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

Proposal on Technology Solution for Lao PDR

1. Introduction

The P-LINK, a project entitled "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. It takes integrative and multi-sectoral approaches in application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea, and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI), and will enlist the support of other UN Agencies.

In the third year of the P-LINK, UNOSSC, STEPI, and three National Mekong Committees agreed on pilot sites and applied technology solutions in Cambodia, Lao PDR, and Viet Nam and are expected to carry out a pilot implementation accordingly. Against this background, STEPI has prepared a proposal on a technology solution for each country.

The main objective of this proposal is to provide a general introduction to a technology solution for the selected pilot site in Lao PDR. In this regard, the proposal first outlines the pilot site and its challenges. It then presents the basic concept and its main components, a review of available technologies for each component, and proposed candidate technologies. Lastly, it concludes with the expected benefits of the technology solution.

2. Site and Local Challenges

Based on the observations from the field visit and desk analysis, the LNMC and STEPI agreed on Nakio village, Mahaxay District, Khammouane Province as a suitable site for the subsequent pilot implementation. The site met three key criteria: 1) conformity with the objectives and directions of the P-LINK, 2) suitability to the WEF Nexus approach, and 3) impact of the project on the social, environmental, and economic aspects.

The local community in Nakio Village has been suffering from floods for more than one month every year during the rainy season, causing severe damage to the livelihoods and property of the local community as well as negative impacts to crop yields.

In this regard, the following possible solution is recommended as one of the possible solutions to mitigate the local challenges faced by the local community in Ban Nakio:

Innovative technologies for real-time flood monitoring and early warning to prevent loss of human lives and livestock, damage to property, and destruction of crops.

- Remote sensing techniques to predict flood
- System to automatically monitor the water level and set off an alarm if the level is too high

Table 1. Analysis on the proposed pilot site

Site	Nakio village, Mahaxay District, Khammouane Province
Location	
Main challenges	Main challenge to tackle is to minimize the severe flooding during the rainy season and to ensure sustainable livelihoods for local farmers.
Suitability to the WEF Nexus approach	**Water issue:** Severe flooding during the rainy season and limited access to sanitary drinking water **Food issue:** Limited irrigation system and severe flooding to reduce the output of crops **Energy issue**: No energy shortage with the grid connection but limited access due to low income level **Others:** Daily livelihood affected

Source: STEPI (2023) P-LINK site selection summary report

3. Technology Review

3.1 Basic concept of FFEWS

A Flood Forecasting and Early Warning System (FFEWS) is a combination of tools and procedures that are used to predict the occurrence of flood events and to provide timely and accurate warnings. Also, WMO (World Meteorological Organization) defines FFEWS as *"linkage between the basic structures"* that *"include provision of specific forecasts with magnitude and timing of rainfall, establishment of a network of hydrometric stations, operation of real-time flood forecasting model software and issuance of early flood warnings"*[1].

The main goal of a FFEWS is to minimize, or ideally prevent, the loss of life and property by allowing sufficient time for the effective evacuation and response to flood events.

A real-time flood forecasting system needs to be connected in an organized manner. This requires: (a) providing specific rainfall forecasts (both quantity and timing) using numerical weather-prediction models; (b) establishing a network of manual or automatic hydrometric stations linked to a central control by some form of telemetry; and (c) flood forecasting model software connected to the observing network and operating in real time.

Flood warnings are distinct from forecasts in that they are issued when an event is imminent or already occurring. Flood warnings must be issued to a range of users and for various purposes. These purposes include: (a) to prepare operational teams and emergency personnel; (b) to warn the public of the timing and location of the event; (c) to warn the likely impacts on roads, dwellings, and flood defence structures, among others; (d) to give individuals and organizations time to prepare; (e) in extreme cases, to allow preparation for the implementation of evacuation and emergency procedures.

According to WMO, FFEWS is the complete framework to promote the enhancement of flood forecasting and early warning capabilities, which is interoperable at all levels from data collection to informing users and decision support system.

Especially, a people-centered flood early warning system empowers individuals and communities threatened by flood hazards to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life, damage to property, assets, and the environment.

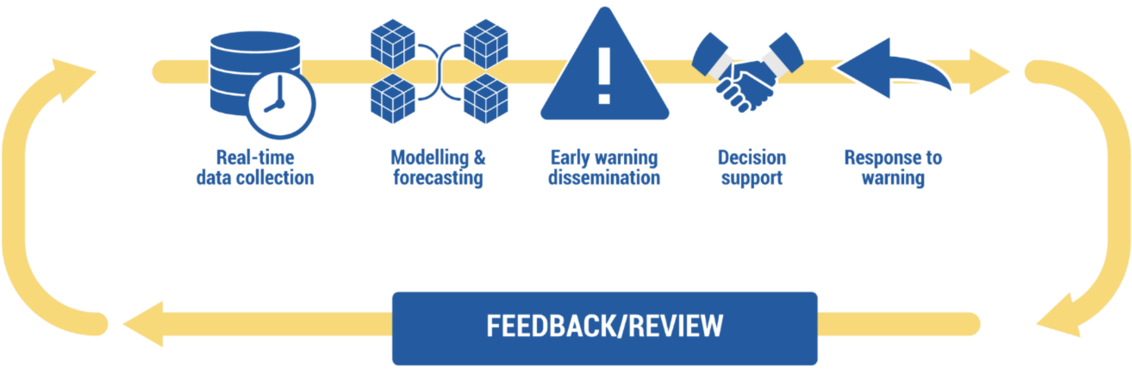

Figure 1. Elements of end-to-end FFEWS[2]

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1 WMO (2011), Manual on Flood Forecasting and Warning.

2 WMO, APFM, E2E-EWS-FF (https://www.floodmanagement.info/get-help/end-to-end-early-warning-systems-for-flood-forecasting-e2e-ews-ff/)

3.2 Components of FFEWS

In 2006 the United Nations released its Global Survey of Early Warning Systems, which identified four elements in natural hazard early warning systems, including flood forecasting: risk knowledge, monitoring and forecasting, warning dissemination and communication, and response capability.

Disaster Risk Knowledge

Risks arise from the combination of hazards, exposure of people and assets to the hazards and their vulnerabilities and coping capacities at a particular location. Assessments of these risks require systematic collection and analysis of data and should consider the dynamics and compounding impacts of hazards coupled with vulnerabilities resulting from unplanned urbanization, changes in rural land use, environmental degradation, and climate change. The level of risk can change depending on the actual impacts and consequences of hazards. Therefore, the risk assessment must include an assessment of the community's coping and adaptive capacities. It is also important to gauge the perception of the level of risk faced by those who are vulnerable. Studies of human interaction and reactions to warnings can also provide insights to improve the performance of early warning systems. Risk assessments should be used to identify the location of vulnerable groups, critical infrastructure, and assets, to design evacuation strategies including evacuation routes and safe areas, and to expand warning messages to include possible impacts. For example, flood maps based on flood risk assessments help to motivate people, prioritize needs and interventions and guide preparations for flood risk management measures, including prevention, preparedness, and response.

Monitoring and Forecasting

Monitoring and forecasting services lie at the core of an early warning system. There must be a sound scientific basis to the system and reliable technology for (i) monitoring and detecting hazards in real time or near real time; and (ii) providing forecasts and warnings 24 hours a day, 365 days a year. It must also be monitored and staffed by qualified people.

Continuous monitoring of hazard parameters is essential to generate accurate warnings in a timely fashion that allow sufficient time for the affected community or communities to enact their disaster management plans appropriate for that hazard. The systems used for detection and monitoring, which could be automated, should allow for strict quality control of the data under international standards when these are available. Warning services should have a multi-hazard perspective (e.g., heavy rainfall may not only trigger flooding but also landslides, the warning for which may come from a separate authority) and be coordinated whenever possible to gain the benefit of shared institutional, procedural and communication networks and capacities. Data, forecasts, and warnings should be archived in a standardized way to support post-event analysis and improvements of the system over time.

Warning Dissemination and Communication

Warnings must reach those at risk. Clear messages containing simple, useful and usable information are critical to enable proper preparedness and response by organizations and communities that will help safeguard lives and livelihoods. Trust is a big part of effective risk communication. If the information source cannot be trusted, those at risk may not respond proactively to the warnings – and it takes a long time to establish trust. Regional, national and local communication systems must be pre-identified and appropriate authoritative voices established. The use of multiple communication channels is necessary to ensure as many people as possible are warned, to avoid failure of any one channel, and to reinforce the warning message.

There are numerous standards and protocols used by alerting authorities to transmit warnings. The Common Alerting Protocol is an international standard format for emergency alerting and public warning, developed by the International Telecommunication Union and promoted by several agencies. It is designed for "all-hazards", that is, hazards related to weather events, earthquakes, tsunamis, volcanoes, public health, power outages, and many other emergencies.

Response Capabilities

It is essential that people understand their risks, respect the national warning service and know how to react to the warning messages. Education and preparedness programs play a key role. It is also essential that disaster management plans include evacuation strategies that are well practiced and tested. People should be well informed on options for safe behavior to reduce risks and protect their health, know available evacuation routes and safe areas and know how best to avoid damage to and loss of property.

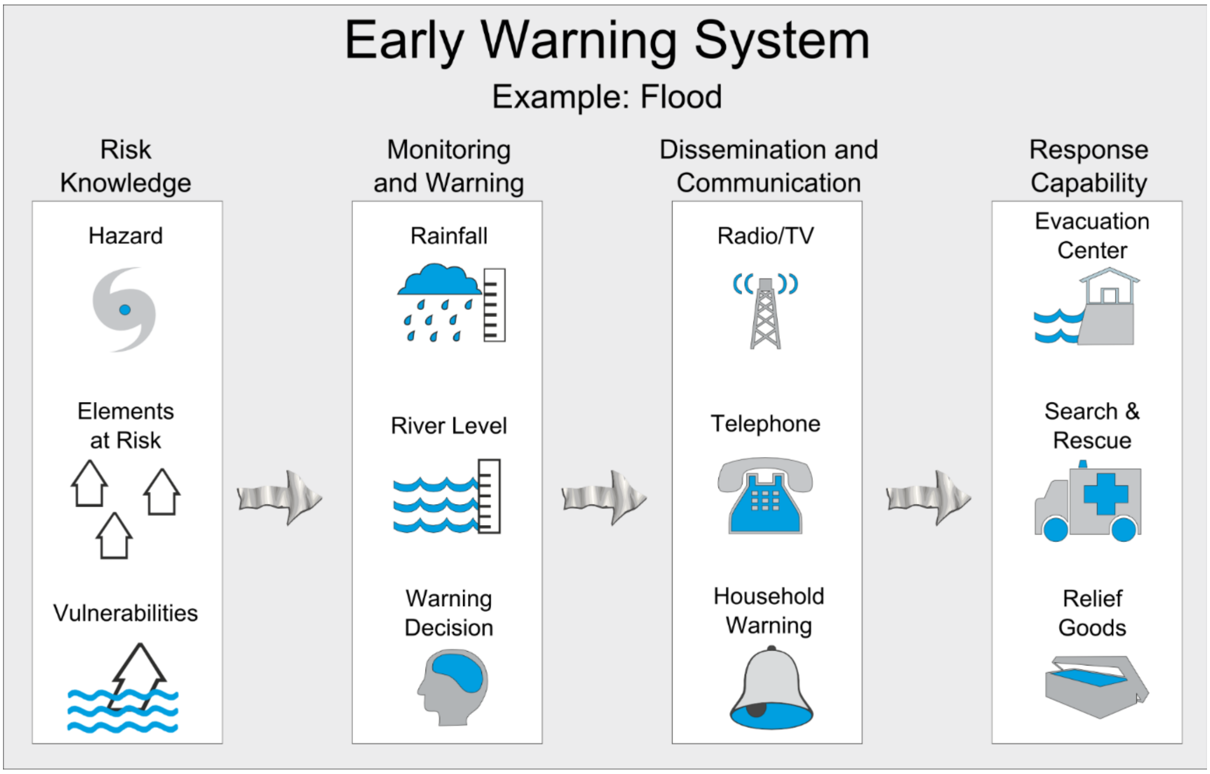

Figure 2. Four components of end-to-end, people-centered early warning systems[3]

3.3 Review of potential technologies in each component

3.3.1 Flood Risk Assessment for the Disaster Risk Knowledge

Flood risk assessment is a process of evaluating the likelihood and potential consequences of flooding in a specific area. It typically involves gathering information about the local geography, hydrology, and climate, as well as existing infrastructure and land use patterns, to determine the

3 UN (2006), Global survey of early warning systems

extent of the risk posed by flooding.

There are several key elements to a flood risk assessment:

- Hazard assessment: This involves identifying the sources of flooding and assessing the likelihood and severity of potential flooding events.
- Vulnerability assessment: This involves evaluating the susceptibility of people, property, and infrastructure to flood damage, based on factors such as building construction, population density, and critical infrastructure.
- Exposure assessment: This involves determining the number and types of assets that could be affected by flooding, such as buildings, roads, bridges, and utilities.
- Risk characterization: This involves combining the hazard, vulnerability, and exposure assessments to determine the overall risk posed by flooding in a particular area.
- Mitigation and adaptation strategies: Based on the results of the risk assessment, strategies can be developed to reduce the risk of flooding or minimize its impacts, such as building flood protection measures or adjusting land use patterns.

Figure 3. Risk as a combination of hazard, exposure and vulnerability[4]

The procedures for conducting a flood risk assessment typically involve the following steps:

1) Define the study area: This involves identifying the boundaries of the area to be studied, such as a watershed or a specific region.
2) Identify sources of flood hazard: This involves identifying the types of flooding that may occur in the study area, such as riverine flooding, coastal flooding, or flash floods.
3) Collect data: This involves gathering information about the study area, including topography, hydrology, climate, land use, and infrastructure. This data can come from a variety of sources, such as satellite imagery, aerial photography, topographic maps, and field surveys.
4) Analyze data: This involves using various tools and techniques to analyze the data collected in step 3, such as hydrologic models, hydraulic models, and geographic information systems (GIS).
5) Assess vulnerability and exposure: This involves identifying the assets that may be at risk from flooding, such as buildings, critical infrastructure, and natural resources, and evaluating their vulnerability and exposure to flood damage.
6) Determine the level of risk: This involves combining the information gathered in steps 2-

4 World Bank, UFCOP (Urban Floods Community of Practice) (2017), Flood risk management at river basin scale

5 to determine the overall level of risk posed by flooding in the study area.

7) Develop mitigation and adaptation strategies: Based on the results of the risk assessment, strategies can be developed to reduce the risk of flooding or minimize its impacts. This may include measures such as land use planning, flood protection infrastructure, and emergency management planning.

8) Communicate findings and recommendations: The results of the flood risk assessment and the recommended strategies should be communicated to stakeholders, such as government agencies, local communities, and private property owners, to promote understanding and collaboration in managing flood risk.

Under the current constraints of this project, the application of Flood Hazard Analysis is more feasible than Flood Risk Analysis. The particular limitations influencing this decision are multifaceted, encompassing factors such as available resources, data availability, and scope of the project.

Flood Hazard Analysis, which focuses on the assessment of potential flood events, their frequency, and the geographical extent of potential inundation, requires fewer resources and less comprehensive data sets compared to Flood Risk Analysis. This makes it a more pragmatic approach in the face of constraints such as limited data availability and project resources.

Flood Risk Analysis, on the other hand, requires a more extensive data set, including not only hydrological and hydraulic data but also socio-economic data. It seeks to evaluate the potential impacts and consequences of flood hazards on the community, infrastructure, and environment. This process necessitates more detailed information about assets at risk, their vulnerabilities, and the potential consequences of flood events. In scenarios where such comprehensive data sets are not readily available or where resources for data collection are limited, executing a thorough Flood Risk Analysis can be challenging.

Therefore, the project, constrained by these factors, is currently oriented towards the application of Flood Hazard Analysis, which will provide valuable insights into the inherent flood hazards within the study area, while aligning with the available resources and data.

3.3.2 Technologies for Flood Detection and Monitoring

AWS (Automatic Weather Station)

An Automatic Weather Station (AWS) is an automated version of a traditional weather station, and it is designed to record meteorological measurements without the need for human intervention. AWS is crucial for capturing detailed, real-time weather data in specific locations, and use of this instrument has become widespread in meteorology, climatology, and in fields like agriculture and aviation.

Weather sensors actually measure the meteorological parameters. The specific sensors can vary based on the needs of the AWS, but common ones include:

- Temperature and Humidity Sensors: These measure the air temperature and relative humidity.
- Barometric Pressure Sensor: This measures the atmospheric pressure.
- Rain Gauge: This measures the amount of precipitation.
- Anemometer and Wind Vane: These measure wind speed and direction.
- Pyranometer: This measures solar radiation.

- Snow Depth Sensor: This measures the depth of snow (used in colder climates).

The AWS can be programmed to record data at specific intervals, such as every minute, every hour, or every day. This data can then be used to understand the local climate, make weather forecasts, inform research studies, and provide critical information to sectors like agriculture, water management, and disaster prevention, among others. Furthermore, advancements in technology are making AWS more capable and diverse. For example, some AWS are now equipped with artificial intelligence capabilities to help analyze data and predict weather patterns. However, the core functionality of an AWS remains the capturing of real-time, localized weather data.

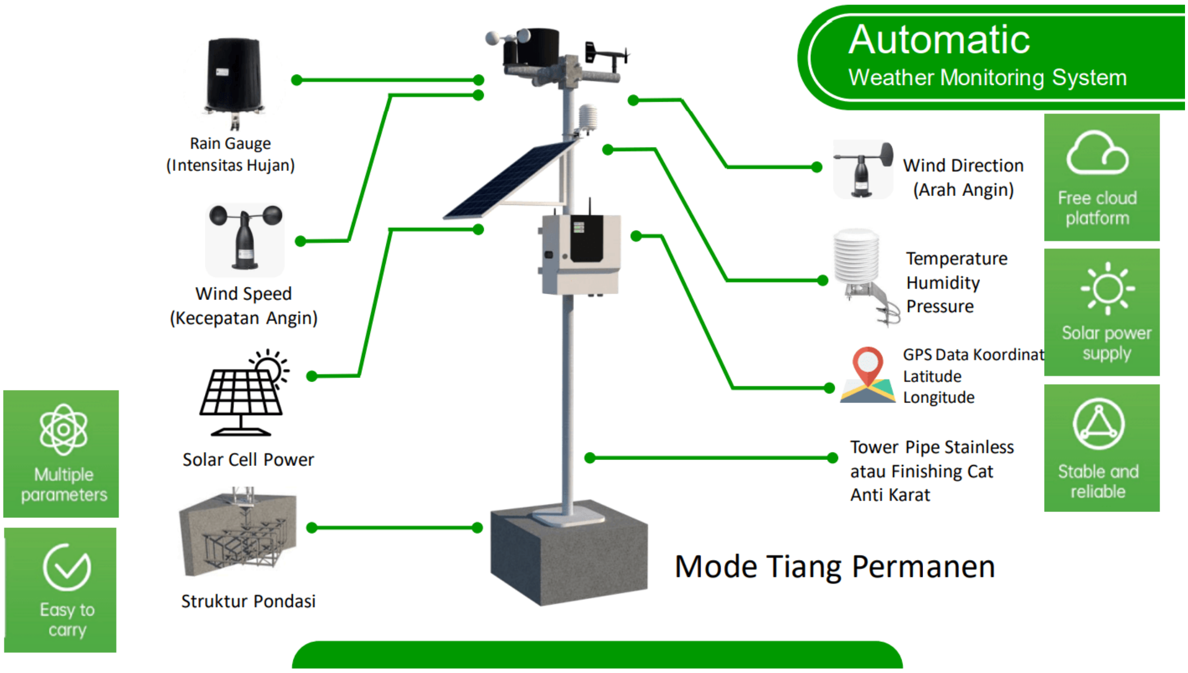

Figure 4. Automatic Weather Station

Weather Radar System

Weather radar is a type of radar used to locate precipitation, calculate its motion, and estimate its type (rain, snow, hail, etc.) and intensity. A weather radar emits radio waves into the atmosphere, which then bounce off precipitation particles and return to the radar. By measuring the time, it takes for the radio wave to return, the radar can determine the distance to the precipitation. The strength of the returned signal gives an indication of the amount of precipitation. Modern weather radars are typically Doppler radars, which can also measure the velocity of the precipitation particles. This is useful for determining wind patterns and can help predict severe weather like tornadoes. Dual-Polarization Radars send out two radio waves with different orientations (horizontal and vertical), which allows them to gather more information about the precipitation. This can be used to distinguish between different types of precipitation (like rain vs. snow), and to estimate the size and shape of the raindrops. Many countries have networks of weather radars that work together to provide comprehensive coverage over a large area. These networks can track storms as they move across the country, providing early warnings of severe weather.

Weather radars can provide estimates of rainfall intensity and total rainfall over a given area.

However, these estimates can be affected by various factors and often need to be calibrated using data from rain gauges. Also, Weather radars are used in meteorology for weather forecasting, in hydrology for flood forecasting, in aviation to provide pilots with up-to-date weather information, and in climate research to study precipitation patterns.

While weather radars provide valuable information, they also have limitations. For example, they can be affected by obstacles like mountains or buildings, and they have a limited range (typically around 200-300 km for most weather radars). They also have difficulty detecting small or low-level precipitation and require skilled technicians to operate and interpret the data. Most of all, weather radar systems can be expensive to install, operate, and maintain.

Due to these limitations of applying weather radar, it will not be included in the project. However, these systems are an essential tool for weather forecasting and hydrological monitoring in the future.

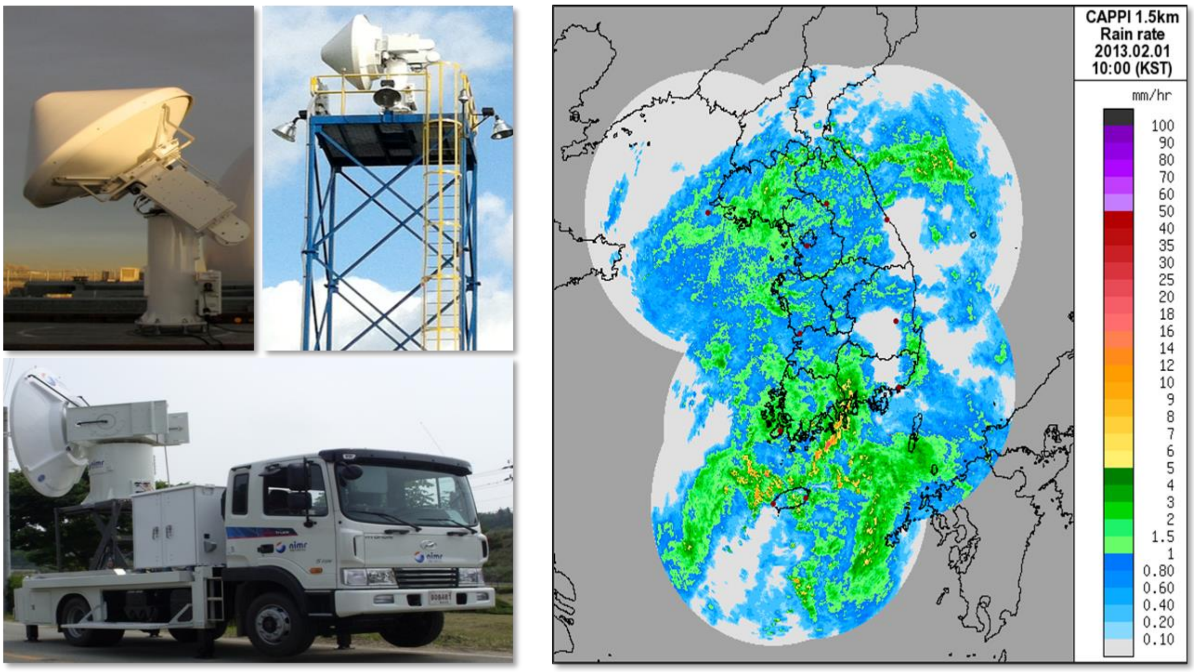

Figure 5. Weather radar systems

Rainfall Gauge Station

Rainfall stations are usually equipped with rain gauges for the specific purpose of measuring the amount and intensity of rainfall over a given period. The key role of rainfall stations in a FFEWS is to provide localized, real-time data on precipitation. This data is critical in determining if, when, and where flooding might occur. The rainfall data, when used in conjunction with river level and weather data, helps in creating accurate flood forecasts and timely warnings.

Rain gauges are devices used to measure the amount of rainfall over a given period. They come in various types, each with its own method of measuring rainfall. Here are some of the most common types of rain gauges:

- Standard Rain Gauge: Also known as a graduated cylinder rain gauge, this is the simplest type of rain gauge. It consists of a cylindrical tube with a funnel at the top that directs rain into the cylinder. The amount of rainfall is measured by marking levels on the cylinder.

The advantage of this type of gauge is its simplicity and ease of use. However, it requires manual reading and emptying, and it can be inaccurate if the rainfall is very heavy or accompanied by strong winds.

- Tipping Bucket Rain Gauge: This is a more complex type of rain gauge. It consists of a small see-saw or "tipping bucket" mechanism inside a collecting funnel. Each time a predetermined amount of rainfall enters the collector, it tips the bucket, causing it to empty and sending an electrical signal to a data logger. The number of "tips" is counted and used to calculate the total rainfall. This type of rain gauge can provide real-time data and can be connected to automatic weather stations. However, it may be less accurate with very heavy rainfall, where it may not be able to tip fast enough.

- Weighing Precipitation Gauge: This type of gauge measures the weight of the collected precipitation to determine the rainfall amount. As rain falls into the collection bucket, the increase in weight is recorded and converted into an equivalent rainfall amount. Some models also have a mechanism to melt snow or ice for measurement. Weighing gauges are generally more accurate than tipping bucket gauges and can handle a wider range of precipitation rates, but they are also more expensive and complex.

- Optical Rain Gauge: This type of gauge uses a row of collection funnels and a light emitter and sensor to measure rainfall. When a raindrop falls through a funnel, it interrupts the light beam, and the sensor records this interruption. By counting the interruptions, the gauge calculates the amount of rainfall. These gauges can be very accurate and can measure rainfall intensity as well as total amount, but they are also more complex and can be affected by things like dust or insects blocking the light beam.

- Acoustic Rain Gauge: This type of gauge measures the impact of raindrops on a surface to calculate rainfall. It uses a microphone to detect the sound of each raindrop hitting the surface, and the number of impacts is used to calculate the rainfall amount. These gauges can be very accurate and can measure rainfall intensity as well as total amount. However, they can also be affected by background noise and require complex signal processing algorithms.

The advantages and disadvantages of a rain gauge are as shown in the following table. Considering factors such as the accuracy, budget, ease of installation, and maintenance, the project intends to utilize a tipping bucket type rain gauge.

Table 2. Pros and Cons of Rain Gauges

Type of Gauge	Pros	Cons
Standard Rain Gauge	Simple and low-cost, no power required	Requires manual reading and emptying, less accurate in heavy rainfall or strong winds
Tipping Bucket Rain Gauge	Provides real-time data, suitable for remote monitoring	Less accurate in very heavy rainfall, requires power source
Weighing Precipitation Gauge	High accuracy, can handle a wide range of precipitation rates	More expensive and complex, requires power source

Type of Gauge	Pros	Cons
Optical Rain Gauge	Very accurate, can measure rainfall intensity and total amount	More complex, can be affected by dust or insects, requires power source
Acoustic Rain Gauge	Very accurate, can measure rainfall intensity and total amount	Can be affected by background noise, requires complex signal processing, requires power source

Water Level Gauge Station

Water level stations are critical components of flood forecasting and warning systems. They provide real-time data on the water levels in rivers and streams, which is essential for flood prediction and management. A river water level station is typically located along a riverbank and features a variety of instruments designed to measure and record changes in water level over time. The core instrument is often a water level sensor, which may operate on various principles such as pressure transducers, ultrasonic sensors, or radar sensors. The choice of sensor type depends on the specific requirements of the monitoring site, including the expected range of water level fluctuations, the presence of debris or sediment, and the required accuracy and resolution of measurements.

Water level gauges are used to measure the level of water in a body such as a river, lake, reservoir, or ocean. This is essential for managing water resources, predicting floods, and ensuring the safety of structures like dams and bridges. Common types of water level gauges are as follows:

- Staff Gauge: This is the simplest type of water level gauge. It is essentially a ruler or graduated staff that is permanently installed in the water body. The water level is read manually by looking at the staff. While this method is simple and low-cost, it does not provide real-time data and can be difficult to read in poor visibility or from a distance.

- Pressure Transducer: This type of gauge measures the pressure of the water above the sensor. Since the pressure at a given depth in a body of water is directly related to the water level, this allows the water level to be calculated. Pressure transducers can provide real-time data and are suitable for remote monitoring. They are usually powered by batteries and transmit the data wirelessly.

- Ultrasonic Level Sensor: These sensors measure the water level by emitting an ultrasonic pulse and measuring the time it takes for the echo to return. This time is proportional to the distance to the water surface, allowing the water level to be calculated. Ultrasonic sensors can provide continuous, real-time data and are suitable for remote monitoring. However, they can be affected by factors like temperature, humidity, and surface turbulence.

- Radar Level Sensor: Similar to ultrasonic sensors, radar level sensors work by emitting a radio wave and measuring the time it takes for the echo to return. However, they use radio waves instead of ultrasonic waves. Radar sensors are more accurate and reliable than ultrasonic sensors, especially in challenging conditions, but they are also more expensive.

- Float Gauge: This type of gauge uses a float that moves up and down with the water level. The position of the float is tracked, providing a measure of the water level. Float gauges can be simple and relatively cheap, but they can also be affected by factors like wave action and debris in the water.

- Bubbler Gauge: A bubbler gauge works by forcing a gas (usually air) through a tube that extends to the bottom of the water body. The pressure needed to force the gas out of the tube is related to the water depth, allowing the water level to be calculated. Bubbler gauges can provide accurate, continuous data and are not affected by factors like surface turbulence or temperature. However, they are more complex and require a continuous supply of gas.

Each type of water level gauge has its advantages and disadvantages, and the choice of which to use can depend on factors like the nature of the water body, the required accuracy, and the available budget. Also, it's worth noting that modern water level gauges often include data loggers and communication equipment to allow for remote monitoring and real-time data collection.

Here is a table summarizing the pros and cons of the various types of water level gauges:

Table 3. Pros and Cons of water level gauges

Type of Gauge	Pros	Cons
Staff Gauge	Simple and low-cost, no power required	Manual reading needed, not suitable for remote monitoring, can be difficult to read in poor visibility or from a distance
Pressure Transducer	Provides real-time data, suitable for remote monitoring, good accuracy	Can be affected by changes in atmospheric pressure, requires power source
Ultrasonic Level Sensor	Provides real-time data, suitable for remote monitoring, non-contact method	Can be affected by factors like temperature, humidity, and surface turbulence, requires power source
Radar Level Sensor	Highly accurate, reliable under challenging conditions, non-contact method	More expensive than other types, requires power source
Float Gauge	Simple, relatively cheap	Can be affected by factors like wave action and debris in the water, moving parts can wear out
Bubbler Gauge	Provides accurate, continuous data, not affected by factors like surface turbulence or temperature	More complex, requires continuous supply of gas, requires power source

Just like with rainfall gauges, the choice of gauge depends on the specific requirements of the measurement task, including factors such as the nature of the water body, the desired accuracy, and the available resources. Considering these factors, the project intends to utilize a radar level type sensor.

Figure 6. Rainfall station (Left) and water level station (Right)

Key Considerations for Selecting Appropriate Equipment

There are a number of important factors to consider when choosing a water level gauge, rainfall gauge, or other hydro-meteorological instrument as follows:

1) **Accuracy**: The accuracy of the instrument is one of the most important factors. Different applications require different levels of accuracy. For instance, if you're using the data for research or for regulatory purposes, you might need a high level of accuracy.
2) **Reliability and Durability**: The instrument needs to be reliable and able to withstand the environmental conditions where it will be installed. This includes factors such as weather extremes, possible flooding, and potential damage from wildlife or human activity.
3) **Cost**: The cost of the instrument is an important consideration. This includes not only the initial purchase price but also the costs of installation, maintenance, and data management.
4) **Maintenance Requirements**: Some instruments require more maintenance than others. For instance, some might need regular cleaning or calibration, while others might have consumable parts that need to be replaced periodically.
5) **Ease of Use**: How easy the instrument is to install, use, and maintain is another important factor. This can be particularly important if the instrument will be used by people with limited technical expertise.
6) **Data Management**: Consider how the instrument will transmit and store data. Does it have built-in data logging capabilities? Does it provide real-time data, and if so, how does it transmit this data? Does it require any specific software to access and analyze the data?

7) **Power Requirements**: Consider the instrument's power requirements. Some instruments can run on batteries or solar power, which can be advantageous in remote locations without access to mains power.

8) **Integration with Other Systems**: If it is necessary to integrate the instrument into an existing system, such as a flood warning system or a weather station, you need to ensure that it's compatible with this system.

9) **Regulatory Compliance**: In some cases, it is necessary to choose an instrument that meets certain regulatory requirements. For instance, some jurisdictions require the use of specific types of instruments for certain applications.

These are just common factors to consider when choosing a hydro-meteorological instrument. The specific factors that are most important will depend on particular needs of the project and local circumstances.

3.3.3 Technologies for Flood Analysis and Forecasting

Generally, a flood analysis model is used for flood forecasting and warning. Flood analysis models are crucial tools used to predict the occurrence, extent, and severity of floods. These models help in the planning and design of flood control systems, urban planning, emergency response, and flood risk assessment. There are many types of flood analysis models, each of these models has its strengths and weaknesses, and the choice of model will depend on the specific requirements of the flood analysis. For example, hydrological models might be used to predict river flow in rural areas, while hydraulic models might be more appropriate for predicting flooding in urban areas. In many cases, multiple models will be used in combination to provide a comprehensive analysis of flood risk.

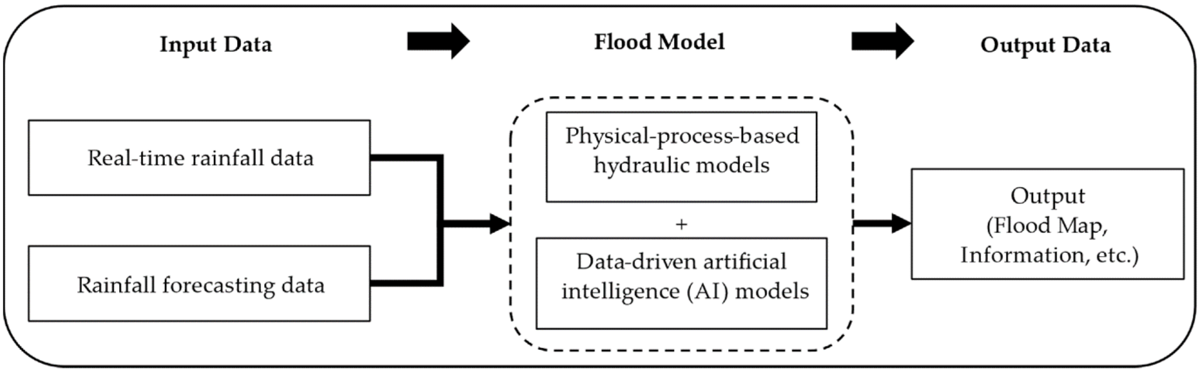

Figure 7. General scheme of flood analysis model

Hydrological Flood Analysis Model

Hydrological models are essential tools for understanding the dynamics of water systems and predicting floods. They simulate the hydrologic cycle and can provide valuable information for flood risk management, water resource management, environmental protection, and climate change studies.

There are several types of hydrological models used for flood analysis:

- Conceptual Models: These models are based on a simplified representation of the actual physical processes involved in the hydrological cycle, such as precipitation, evapotranspiration, infiltration, and runoff. They use a series of interconnected storage components and flow pathways to represent these processes. The parameters of these models are usually physically meaningful but need to be calibrated using observed data. An example of a conceptual model is the Stanford Watershed Model.
- Physically-Based Models: These models aim to describe the physical processes involved in the hydrological cycle as accurately as possible using mathematical equations based on the laws of physics. They require detailed information about the catchment, such as soil type, vegetation, and topography. Due to their complexity and data requirements, they are often used for smaller catchments. Examples include the MIKE SHE model and the HydroGeoSphere model.
- Empirical Models: These models are based on statistical relationships between hydrological variables, derived from observed data. They do not attempt to represent the physical processes but rather rely on observed patterns in the data. They are often used when data is scarce, or the system is too complex to be represented accurately by other types of models. An example is the Rational Method, used for estimating peak discharge in a catchment.
- Stochastic Models: These models incorporate the role of randomness in the hydrological cycle. They are often used in conjunction with other types of models to account for the inherent uncertainty in hydrological processes. Examples include autoregressive models and Markov chain models.
- Distributed Models: These models represent the spatial variability of hydrological processes across a catchment. They require spatially distributed data and often use Geographic Information System (GIS) tools. Examples include the SWAT (Soil and Water Assessment Tool) model and the TOPMODEL.
- Lumped Models: These models represent a catchment as a single unit or a few large units, ignoring spatial variability. They require less data and computational resources compared to distributed models and are often used for large catchments or when data is limited. An example is the HBV (Hydrologiska Byråns Vattenbalansavdelning) model.

Hydrological Flood Analysis Model

Hydraulic models are essential tools for understanding and predicting how water moves through river channels and floodplains. They simulate the flow of water, taking into account the physical characteristics of the river or floodplain, such as channel geometry, bed roughness, and hydraulic structures, and can provide valuable information for flood risk management, river engineering, and environmental protection.

There are several types of hydraulic models used for flood analysis:

- 1D (One-Dimensional) Models: These models represent flow in one dimension, usually along the river channel. They are typically used for river and channel design, floodplain mapping, and flood forecasting. They require less computational resources compared to higher dimensional models, making them suitable for large-scale applications. However, they may not accurately represent complex flow patterns in wider floodplains. Examples include the HEC-RAS (Hydrologic Engineering Centers River Analysis System) and MIKE 11 models.
- 2D (Two-Dimensional) Models: These models represent flow in two dimensions, both

along and across the river. They are more accurate than 1D models in representing complex flow patterns, such as those in wide floodplains, around hydraulic structures, and in urban areas. However, they require more data and computational resources. Examples include the TUFLOW and MIKE 21 models.

- 3D (Three-Dimensional) Models: These models represent flow in all three dimensions. They are the most accurate but also the most data and resource-intensive. They are typically used for detailed studies of complex hydraulic phenomena, such as flow around bridge piers or in estuaries. Examples include the MIKE 3 and TELEMAC-3D models.
- Hybrid Models: These models combine different types of models to take advantage of their respective strengths. For example, a 1D model may be used to represent flow in the river channel, while a 2D model is used to represent flow in the floodplain. This allows for more accurate simulations without the computational burden of a full 2D or 3D model. Examples include the HEC-RAS (with 1D and 2D capabilities) and MIKE FLOOD (combining MIKE 11 and MIKE 21).

Data-driven Model

Data-driven models for flood forecasting leverage statistical and machine learning techniques to predict flood events based on historical data. These models do not explicitly simulate the physical processes involved in floods, but instead identify patterns and relationships in the data that can be used to make predictions. They can be an effective tool for flood forecasting, particularly in cases where detailed physical data is lacking or the hydrological processes are poorly understood. There are several types of data-driven models used in flood prediction, including statistical models, machine learning models, and hybrid models:

- Statistical Models: These models use historical data to identify statistical relationships between different variables (such as rainfall, river flow, and soil moisture) and the occurrence of floods. These relationships are then used to predict future events. For example, regression models can be used to predict river flow based on rainfall and other factors. Linear regression is the simplest form, but other types like multiple regression, logistic regression, and polynomial regression can also be used depending on the complexity of the relationships in the data.
- Machine Learning Models: These models use algorithms to learn from historical data and make predictions about future events. There are many types of machine learning models used in flood prediction, including decision trees, neural networks, support vector machines, and ensemble models. Especially, deep learning is a type of machine learning that uses neural networks with many layers (hence "deep"). These models can learn very complex patterns and have been used for a range of applications, including flood forecasting. Also, these machine learning models can handle complex, nonlinear relationships between variables and can often provide more accurate predictions than traditional statistical models.
- Hybrid Models: These models combine elements of both statistical and machine learning models to improve prediction accuracy. For example, a hybrid model might use a statistical model to identify key variables and relationships, and a machine learning model to refine these relationships and make predictions.

When using data-driven models for flood prediction, it's important to consider the quality and availability of data. Good models require reliable, high-quality data, and they need to be updated regularly to reflect current conditions. In addition, these models should be validated using independent data to ensure their accuracy.

Finally, while data-driven models can provide valuable insights for flood prediction, they are just one tool in the toolbox. They should be used in combination with other approaches, such as physical models and expert judgement, to provide a comprehensive understanding of flood risk.

Implementation of Flood Analysis Model

When selecting a flood analysis model for a FFEWS, several key considerations should be considered. These include not only the specific hydrological and meteorological characteristics of the region, but also the availability of skilled personnel, ease of application, and the sustainability of the forecasting system.

The selection of a suitable model is crucial, as the model's performance can significantly affect the accuracy and reliability of flood forecasts. However, due to the complex nature of flood processes, developing and implementing a suitable flood model often requires a significant level of expertise in hydrology, hydraulics, and computational modelling. This expertise may not always be readily available, particularly in regions with limited resources or capacity. Furthermore, even when such expertise is available, the development and calibration of a complex model can be a time-consuming and challenging task.

Given these constraints, it may be beneficial to consider the use of data-driven models for flood forecasting. Data-driven models, such as machine learning models, rely on historical data to predict future events. They do not require explicit representation of physical processes, which can make them simpler to develop and apply compared to traditional physically-based models. This can be a significant advantage in situations where there is a lack of flood modelling experts or where rapid deployment of a forecasting system is required.

Moreover, data-driven models can potentially offer a more sustainable solution for flood forecasting. Once developed and trained, these models can continue to provide reliable forecasts without the need for continuous input or adjustment by experts. This can make them particularly suitable for long-term, operational flood forecasting systems.

Therefore, in the context of project, where the goal is to provide reliable and sustainable flood forecasts, the application of data-driven models may be a promising approach. This is particularly the case in situations where there are constraints in terms of expertise, resources, or time.

3.3.4 Flood Alert and Dissemination

Flood alerts and dissemination of warning messages are vital components of a FFEWS. They ensure that information about potential flood events is communicated effectively to people at risk, enabling them to take appropriate actions to protect themselves and their property. There are several types of devices and instruments used for this purpose:

- Sirens and Loudspeakers: These are often installed in public places and used to broadcast emergency warnings to large areas. They are particularly useful in densely populated areas or in areas where other forms of communication may not be reliable.
- Radio and Television Broadcasts: Public radio and television networks can be used to broadcast flood warnings to a large audience. These channels are often used in conjunction with other methods to ensure that the message reaches as many people as possible.

- Mobile Alerts: With the widespread use of mobile phones, SMS or app-based alerts have become an effective way to deliver warnings directly to individuals. In many cases, these alerts can be location-specific, ensuring that only those at risk receive the warning.
- Internet and Social Media: Websites, email alerts, and social media platforms like Facebook and Twitter can be used to disseminate flood warnings. These platforms can reach a wide audience quickly and allow for real-time updates.
- Community-Based Alert Systems: In some cases, particularly in rural or remote areas, community-based alert systems may be used. These could involve local volunteers who are trained to disseminate warnings to their communities.
- Automated Telephone Dialling Systems: These systems can automatically dial a list of phone numbers and deliver a pre-recorded warning message. They can be effective for reaching a large number of people in a short period.

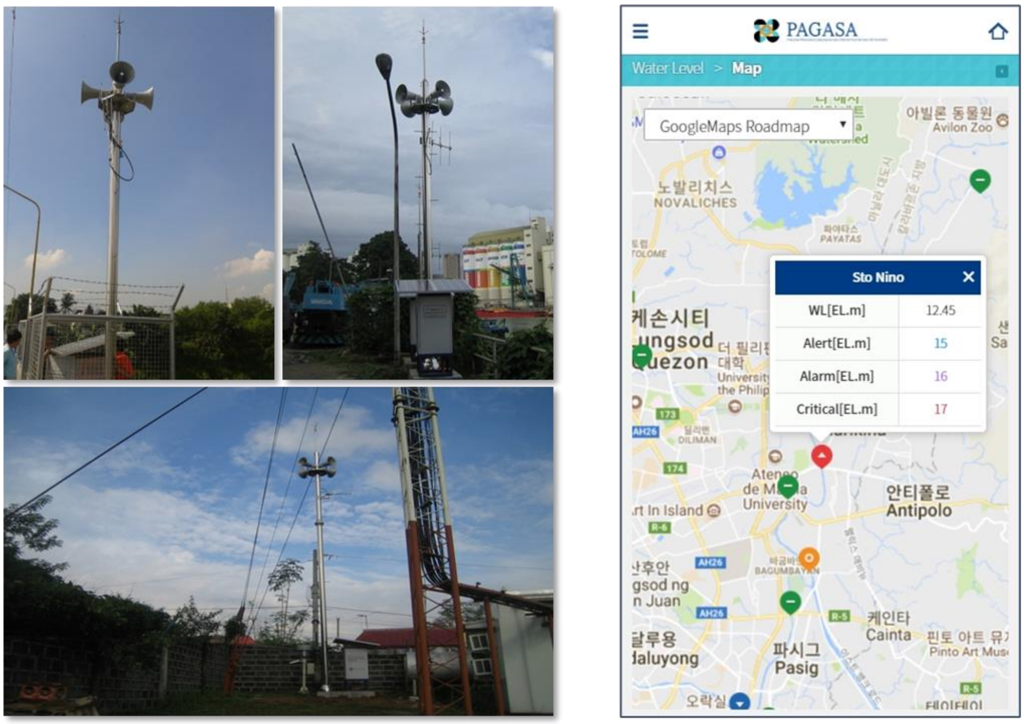

Figure 8. Warning Post with siren (Left) and mobile app. (Right)

When selecting devices or instruments for flood alert dissemination, several factors need to be considered. These include the reach of the device, the reliability of the communication channel, the ability to target specific areas or populations, and the likely responsiveness of the audience to the alert method. The selection should ideally be based on a thorough understanding of the target population's communication habits and preferences. It is also important to use local languages and culturally appropriate messaging to ensure that the information is understood and taken seriously.

For the rural areas of Lao PDR in this project, a combination of methods could be utilized to ensure maximum reach and efficacy of the flood alert and dissemination system as follows:

1) **Community-Based Alert Systems**: Due to potential limitations in technology

infrastructure and literacy in rural areas, community-based alert systems can be highly effective. Training local volunteers to interpret flood forecasts and warnings can allow for timely dissemination of this information to the rest of the community.

2) **Sirens and Loudspeakers**: In villages, where houses are often close together, sirens or loudspeakers could be installed at central points to alert residents of impending floods. These are particularly useful when immediate action is required.

3) **Mobile Alerts**: Where mobile phone penetration is high, SMS-based alerts can be an efficient way to deliver warnings directly to individuals. This could be particularly useful for people in remote areas or out in the fields.

4) **Public Meetings and Notices**: In some cases, particularly for slow-onset floods, public meetings can be held to inform residents of the flood risk. Similarly, notices could be posted at community gathering points.

Figure 9. Example of local flood warning system (Mozambique)

4. Candidate Technology solution

Given the review of the various technical elements, the project is intended to facilitate the implementation of a Local Flood Early Warning System (LFEWS). LFEWS is a community-centric solution aimed at enhancing the ability of local authorities and municipalities to predict, warn, and respond effectively to flood events at the catchment area level[5]. This system builds on local knowledge and capacity and is designed, tested, and maintained in collaboration with the community to ensure its effectiveness and acceptance. Through the use of LFEWS, the project aims to empower the local community with real-time, pertinent flood-related information,

5 GIZ (2012), LFEWS (Local Flood Early Warning System)

thereby enabling a prompt and appropriate response to potential flood events.

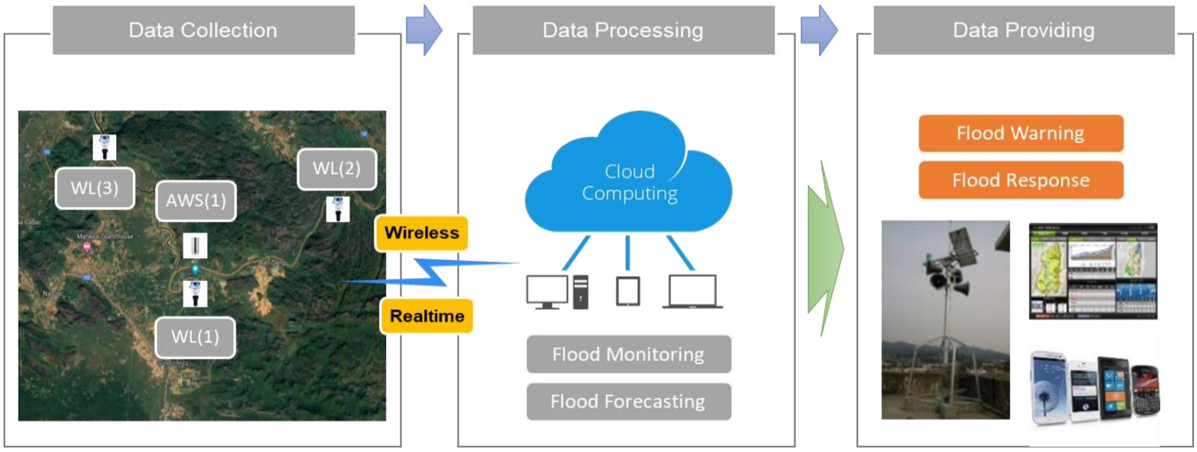

Figure 10. System configuration for the project

In order to identify the causes of floods and select appropriate locations for the installation of flood monitoring equipment, a comprehensive flood hazard analysis is planned to be conducted. It is also proposed to deploy one AWS and three river water level stations for comprehensive and accurate flood monitoring. These river water level stations will be strategically positioned at the target area, upstream, and downstream of the Nam Theun 2 Power Station.

To enable effective flood analysis and prediction, the employment of a data-driven model is proposed. This approach is advantageous due to its adaptability and ability to handle complex, non-linear relationships between different hydrological variables (rainfall-water level or upstream & downstream water level), thereby facilitating accurate and reliable flood forecasting.

Furthermore, considering the management of IT infrastructure and the sustainable operations, the project plans to adopt a cloud computing environment. The implementation of a cloud-based system can facilitate streamlined data management, enhanced computational capabilities, and improved accessibility, while reducing the need for physical infrastructure. This approach not only aligns with modern digital transformation strategies but also supports sustainability by offering scalable resources, heightened system reliability, and reduced operational costs.

Finally, a multi-faceted approach will be implemented to ensure prompt and widespread dissemination of flood warnings. This includes the use of sirens for immediate local alerts, SMS for direct and personal notifications, and community-based alert systems for leveraging local networks and knowledge. This combined approach aims to guarantee the rapid propagation of flood warnings, thereby enabling the community to take the necessary precautions and actions in a timely manner.

5. Expected benefits (social, environmental, economic perspective)

To the local community the Local Flood Early Warning System (LFEWS) can bring several benefits across social, environmental, and economic perspectives, which are explained below.

Social benefits:

1) **Safety:** Early warning of floods can save lives by giving people sufficient time to evacuate or prepare for the flood.

2) **Community Engagement**: LFEWS are designed to be people-centered, meaning that they incorporate local knowledge and capacities. This approach ensures that the systems are designed, tested, and maintained together with the community, enhancing their effectiveness and sustainability.

3) **Education:** These systems can also increase public awareness of flood risks and how to respond when a warning is issued.

Environmental benefits:

1) **Preservation of ecosystems:** By predicting floods, LFEWS can help protect vulnerable ecosystems from damage.

2) **Reduced pollution:** With early warning, potential pollutants can be secured so that they don't contaminate floodwaters.

3) **Biodiversity protection:** By predicting floods, LFEWS can contribute to the protection of local biodiversity. Floods can sometimes dramatically alter habitats and displace or harm wildlife. If communities have advance warning of flooding, they may be able to take actions to mitigate these impacts, thereby helping to protect local biodiversity.

Economic benefits:

1) **Damage control:** Early warnings can help minimize property damage by giving people more time to protect their homes and possessions.

2) **Reduced recovery costs:** Minimizing the impact of floods can lead to less money needed for recovery and rebuilding efforts.

3) **Business continuity:** For businesses, an early warning can allow for measures to protect assets and ensure business continuity.

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30 October 2023

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

Proposal on Technology Solution for Bung Khla Sub-district, Bueng Kan Province, Thailand

1. Introduction

The P-LINK, a project entitled "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. It takes an integrative and multi-sectoral approaches in application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation (SS & TrC) modalities. The five-year project is supported by the Ministry of Science and ICT (MSIT), Republic of Korea, and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI), and will enlist the support of other UN Agencies.

In the third year of the P-LINK, UNOSSC, STEPI, and four National Mekong Committees agreed on pilot sites and applied technology solutions in Cambodia, Lao PDR, Thailand and Viet Nam that were presented during the 2nd Regional Stakeholder Forum on 31 August 2023. These national pilots are expected to be officially rolled out from 2024 Q1.

Thailand has proposed a pilot project focused on enhancing tap water system efficiency in Bung Khla Sub-district, Bueng Kan Province. To better identify the local needs and situation, the Project Team and the Thailand National Mekong Committee Secretariat (TNMCS)/Office of National Water Resources (ONWR) visited the site with a ROK technical expert on 20 October 2023.

Against this background, STEPI has prepared a proposal on a technology solution for Thailand. The main objective of this proposal is to provide a general introduction to a technology solution for the selected pilot site- Moo[1] 1,2 and 3 in Bung Khla Sub-district, Bueng Kan Province. In this regard, the proposal first outlines the pilot site and its challenges. It then presents the basic concept and its main components, a review of available technologies for each component, and proposed candidate technologies. Lastly, it concludes with the expected benefits of the technology solution.

[1] Moo is short for Mooban (moo meaning "group" bahn meaning "house" mooban = village), source ONWR

2. Site and Local Challenges

Based on the observations from the field visit and desk analysis, the TNMCS/ONWR and STEPI agreed on Bung Khla Sub District, Bung Kan District, Thailand as a suitable site for the subsequent pilot implementation. The site met three key criteria: 1) conformity with the objectives and directions of the P-LINK, 2) suitability to the WEF Nexus approach, and 3) impact of the project on the social, environmental, and economic aspects.

The designated pilot site for a Smart Water Management (SWM) initiative faces notable concerns. Predominantly, there is a significant rate of water loss, representing both resource waste and financial setbacks. Compounding this issue is the increasing water demand due to population growth. Adding to the urgency, the water quality supplied is less than ideal, posing potential health threats. There is an evident gap in specialized expertise in waterworks operations, leading to subpar operational practices. Collectively, these challenges underscore the necessity of the SWM project for a sustainable, efficient, and safe water supply for the community.

In this regard, the following possible solution is recommended as one of the possible solutions to mitigate the local challenges faced by the local community in Bung Khla:

Smart Water Management System

for solving the challenges of water loss, water energy, water quality, water scarcity.

- Supervisory control & data acquisition (SCADA) and Optimized Operation System
- Intelligent Water Loss Management System
- Smart non-revenue water (NRW) Management with Water Billing System

Table 1. Analysis on the proposed pilot site

Site	Bung Khla Sub District, Bung Kan District, Thailand
Location	

Main challenges	The pilot site earmarked for the smart water management (SWM) pilot project presents several pressing challenges: 1) High Water Loss: One of the most acute issues is the significant water loss. This not only means wasted resources but also potential financial losses and inefficiencies in the delivery system. 2) Rising Population Demands: As the population of the area grows, so does the demand for water. Ensuring a consistent and adequate water supply to meet this escalating demand becomes paramount, especially in light of the existing inefficiencies. 3) Compromised Water Quality: The quality of water being supplied is suboptimal. Consuming or using low-quality water poses health risks to the residents and can degrade trust in the water utility. 4) Lack of Expertise: The waterworks operations at the site suffer from a lack of specialized knowledge and expertise. This can lead to further operational inefficiencies and make the system more susceptible to breakdowns or malfunctions. 5) Inefficient Operations: The current modus operandi of the waterworks lacks the streamlined processes and modern techniques required for optimal performance. This inefficiency exacerbates the challenges of water loss and supply issues. Addressing these challenges is crucial for the successful implementation of the SWM pilot project and ensuring a sustainable water supply for the pilot site's residents.
Suitability to the WEF Nexus approach	Smart Water Management (SWM) is intrinsically aligned with the Water-Energy-Food (WEF) Nexus, advocating for a synergistic and sustainable approach to managing our planet's vital resources. SWM is all about using water wisely. By reducing wasted water and using it efficiently, we make sure there's always enough. This steady supply of water is not just for drinking, but also important for making energy and growing food. So, water connects directly to both energy and food. Better water quality is a big part of SWM too. Clean water means safer and better food because we often use water to grow crops. And when water is clean to start with, we save energy because it takes less effort to make it even cleaner for use. SWM uses smart methods to meet the needs of more and more people without wasting resources. It uses new technology to stay ahead of challenges and changes in how we use water, energy, and food. In short, SWM looks at the problems in water use, finds solutions, and in doing so, helps in the areas of energy and food too. This whole idea matches perfectly with the WEF connection, showing how everything is linked together. At the heart of SWM lies the potential to address the water facet of the WEF Nexus. By curbing water loss and optimizing its use, SWM ensures a consistent water supply. This is essential not only for direct consumption but also to meet the water requirements of energy generation processes and agricultural endeavors, thereby intertwining water with both energy and food.

Source: STEPI (2023) P-LINK site selection summary report

3. Technology Review

3.1 Basic concept of Smart Water Management (SWM)

In our ever-evolving world, the nexus between technology and resource management is not just advantageous but essential. The Smart Water Management (SWM) concept emerges as a beacon in this fusion, offering a holistic approach to the way we view and handle our most precious resource: water.

At the heart of SWM lies the ambition to encompass the entire water cycle. This starts from the meticulous analysis of prevailing water conditions and extends to the scientific purification, distribution, use, and eventual recycling of water. Unlike traditional systems that might view these stages in isolation, SWM sees them as interconnected cogs of a larger mechanism.

While traditional water management often centers on the resource itself, SWM pivots to a supply network-oriented approach. This ensures not just the stability and safety of the water, but also the efficiency of its distribution through a designed Smart Water Network.

Drawing inspiration from the Republic of Korea (ROK)'s vast experience in water management, SWM marries these proven methods with state-of-the-art information & communications technology. Through this integration, the system gains predictive and adaptive capabilities, making it more resilient and efficient.

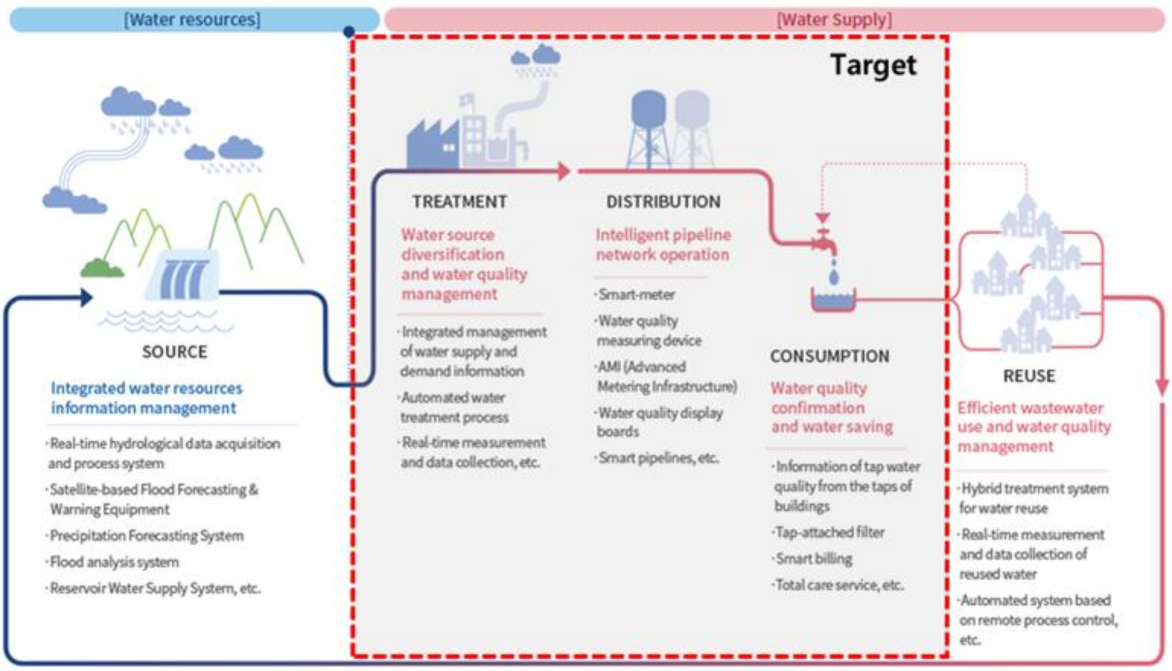

Figure 1. SWM Concept Map

Central to SWM's operation is a network of intelligent sensors that constantly communicate through wired and wireless channels using an array of smart devices. This network not only monitors but also forecasts, allowing for preemptive actions and ensuring continuous service.

SWM stands out in its dedication to the consumer. With its focus on a service system tailored for the end user, it promises a water management experience that's transparent, interactive, and responsive.

Figure 2. 3S Components of SWM

3.2 Components of SWM in waterworks

Smart Water Management (SWM) for waterworks stands as a testament to the amalgamation of technology and effective water management practices. The efficiency and effectiveness of SWM can be attributed to its foundational components, each designed to address specific challenges and streamline the water supply process. Figure 3 illustrates integral components of SWM.

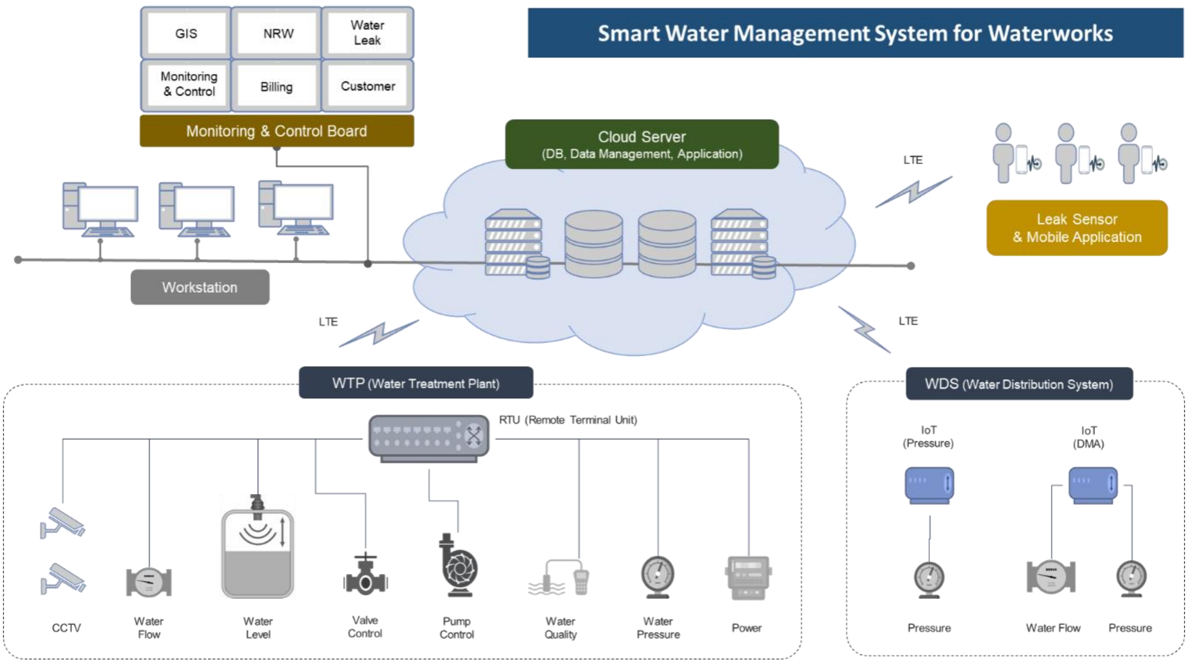

Figure 3. Architecture of SWM System in waterworks

The evolution of Smart Water Management (SWM) in waterworks marks a significant stride towards sustainable water use and efficient infrastructure management. At its core, SWM is bifurcated into two primary domains: the Water Treatment Plant (WTP) and the Water Distribution System (WDS).

The SWM approach in the WTP primarily emphasizes energy conservation and the enhancement of water quality. This involves real-time monitoring of water flow, pressure, and quality. Furthermore, the technology enables the optimized operation of pumps and tanks, ensuring that water is treated efficiently while minimizing energy usage. The goal here is twofold: to provide high-quality water while leveraging technology to reduce energy consumption.

On the other hand, the WDS focuses intently on the challenges of Non-Revenue Water (NRW) and broader water loss management. Additionally, it looks into enhancing water services. The SWM systems in place track the water flow and pressure within District Metered Area (DMA), allowing for better control and rapid response to anomalies. Another crucial component is the management of customers and billing. By integrating advanced monitoring systems, WDS ensures accurate billing, fostering trust among consumers and promoting timely payment of water utility bills.

In essence, the Smart Water Management summarizes a forward-looking approach to waterworks, prioritizing efficiency, quality, and customer service through technology-driven solutions. The synergy between SWM for WTP and WDS provides a comprehensive framework for holistic water resource management, ensuring a sustainable future for urban water supply systems.

Supervisory Control and Data Acquisition (SCADA) with Optimized AI System

SCADA stands for Supervisory Control and Data Acquisition. It is an industrial system framework that enables monitoring and control of both local and remote equipment with code through human-machine interface (HMI) software.

Human-Machine Interface (HMI): The HMI is the graphical representation where human operators can see the processes and interact with them. It displays data from sensors, allows for control of devices, and provides a visual interpretation of complex operations.

Remote Terminal Units (RTUs): These are hardware interfaces that are placed at remote locations to convert sensor signals into digital data and send them to the central system. They can also receive commands from the central SCADA system to control a process or equipment.

Servers and Databases: These store the gathered data, allowing for trend analysis, reporting, and storing of historical data.

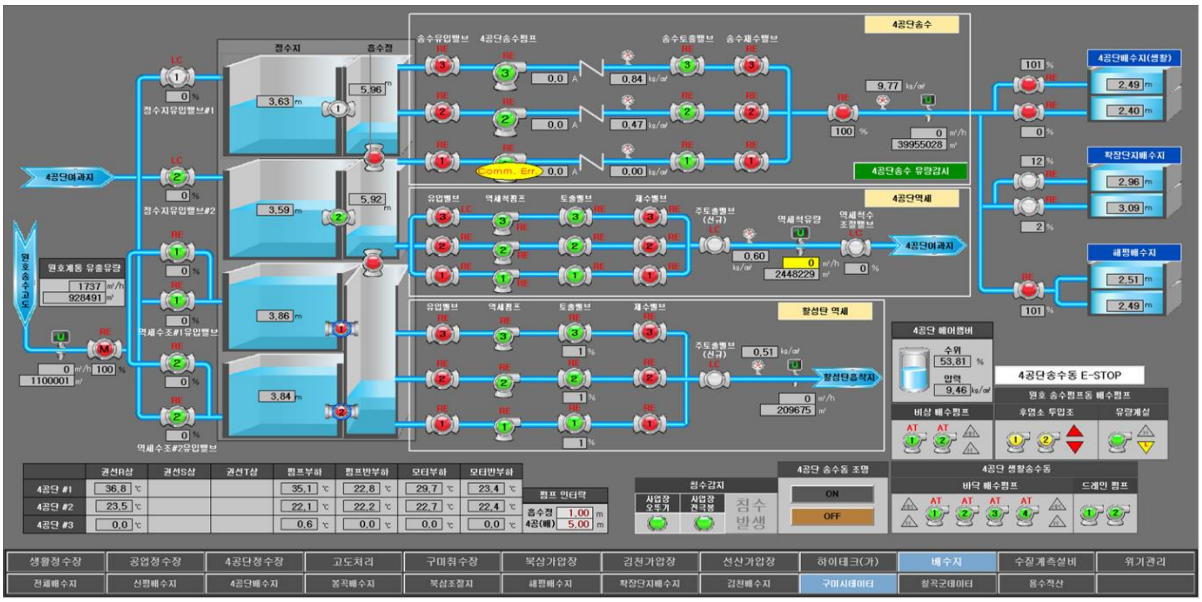

Figure 4. Screen Example of HMI

The Bung Khla pilot project proposes pump supervisory control, chemical injection facility supervisory control, flow rate, water quality, water level, and water pressure monitoring functions.

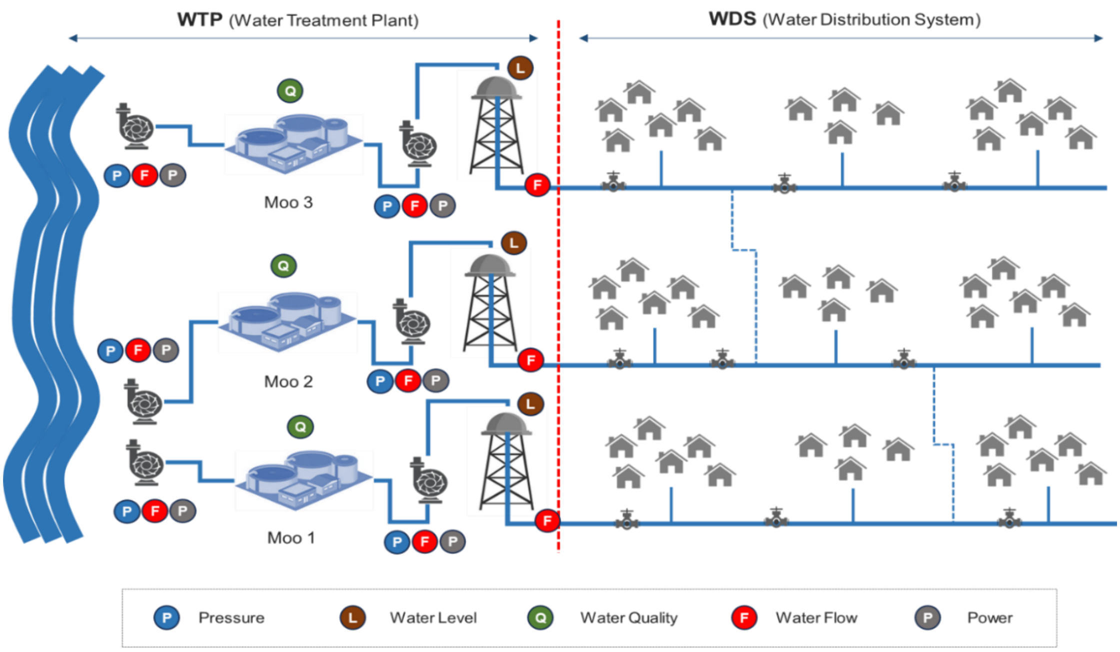

Figure 5. Concept Map of Sensors for SCADA in Bung Khla

Artificial Intelligence (AI) based optimized operation system is a system that predicts water demand and raw water quality with AI models to save energy and improve tap water quality through optimal pump control and chemical injection.

In the realm of waterworks, striking the right balance between energy consumption and water quality is paramount. Leveraging modern technology, especially AI offers unprecedented advantages in refining and optimizing these operations.

Water Energy Reduction with AI:

Forecasting Water Usage: A foundational step in reducing energy consumption in waterworks is understanding and predicting water usage patterns. With AI, it's possible to analyze vast and complex data sets, including historical usage patterns, weather forecasts, and other variables that influence water consumption. By predicting water demand accurately, utilities can ensure they're not over-pumping or maintaining unnecessary water levels in storage facilities, thereby saving energy.

Optimized Pump Control: Pumps, often being the most significant energy consumers in water distribution systems, need meticulous management to ensure efficiency. With AI-driven controls, pumps can operate at optimal times and speeds that align with the demand forecast. For instance, pumps can be scheduled to operate during off-peak energy hours, ensuring lower energy costs and reduced carbon footprint.

Water Quality Improvement with AI:

Optimized Chemical Injection: Water treatment often requires the addition of specific chemicals to remove contaminants, balance pH, or disinfect. Determining the precise amount and timing for these chemicals is crucial for both cost efficiency and ensuring water safety. AI can analyze variables like incoming water quality, temperature, and flow rates in real-time, adjusting the chemical dosages accordingly. This not only ensures that the water remains at the highest quality standards but also minimizes chemical wastage and associated costs.

In essence, the integration of AI into waterworks operations marks a significant leap forward. By offering predictive insights and automated control, AI facilitates a more sustainable, efficient, and high-quality water distribution system. As we move towards a future where resource conservation and quality assurance are of utmost priority, such technologies stand out as invaluable assets in the water industry's toolkit.

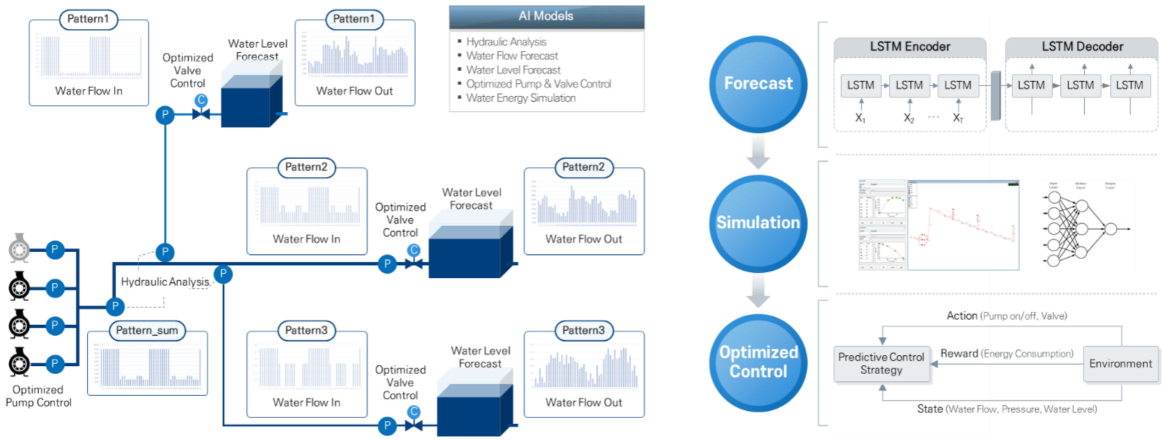

Figure 6. Concept Map of AI based Optimized Operation System

Intelligent Water Loss Management System

The Intelligent Water Loss Management System emerges as an epitome of how innovation can transform essential services. Merging the powers of IoT, AI, and mobile and cloud based remote data capabilities, this system offers a comprehensive and user-friendly approach to water leak detection.

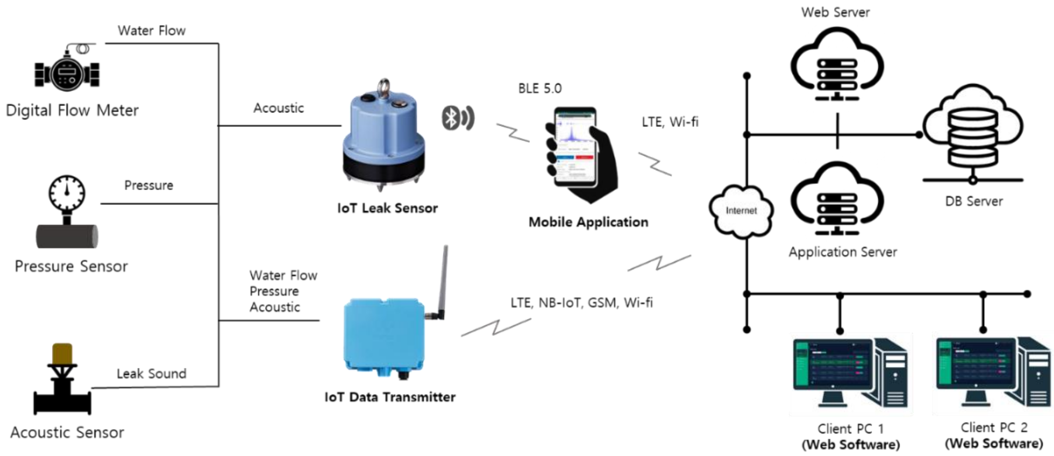

Figure 7. System Architecture of Intelligent Water Loss Management System

It consists of Leak Monitoring, Detection and Pressure Control by using IoT Leak Sensor, IoT Data Transmitter, Cloud Server, Mobile Application, and Web Analysis System.

1) Leak Monitoring in DMA (District Metering Area)

The District Metering Area (DMA) are critical zones within a water distribution network, playing an essential role in understanding and managing water flow and pressure. The Smart DMA Monitoring System emerges as an innovative solution to manage water loss more efficiently.

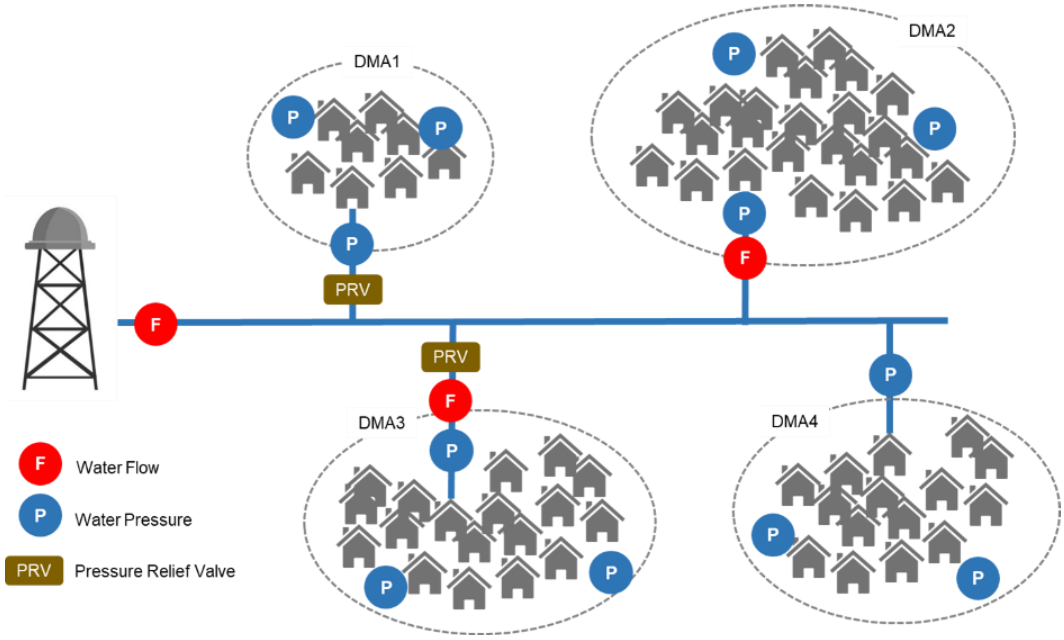

Figure 8. General Concept of DMA Leak Monitoring

The DMA Monitoring System offers real-time insights into the water flow and pressure within each DMA. By continuously tracking and assessing the flow and pressure, utilities can promptly detect anomalies, identify potential issues, and take corrective actions, ensuring optimal water distribution and minimizing disruptions.

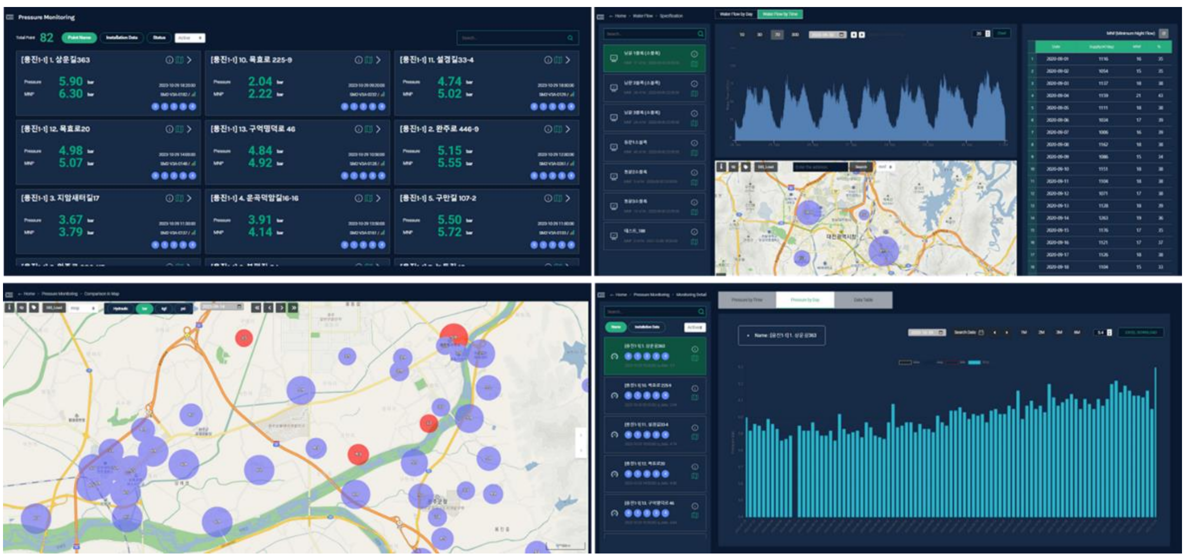

Figure 9. Screen Example of Leak Monitoring System

In general, water leaks are monitored by analyzing Minimum Night Flow (MNF) and Maximum Night Pressure (MNP) of the DMA. MNF and MNP refer to the water flow and pressure within DMA during the hours typically characterized by the lowest consumption, usually between 3 am and 5 am. During these hours, the majority of households and businesses are inactive, resulting in reduced water usage and increased water pressure.

Monitoring MNF and MNP is a crucial tool in water leak detection. Any significant flow and pressure change during this period, can be indicative of potential leaks or unauthorized usage within the DMA.

The pressure monitoring method is a cost-effective method as it can narrow down suspected water leak areas at a lower cost than the flow monitoring method. Generally, the flow monitoring method is used to monitor water leakage in a large area, and the pressure monitoring method is used to monitor water leakage in a small area.

2) Leak Detection

The Intelligent Water Loss Management System, integrating IoT, mobile apps, and cloud tech, revolutionizes water conservation. It utilizes IoT sensors alongside mobile devices to capture sounds from water meters and valves. Users record these sounds on their phones, which are then sent to a cloud server. There, AI models analyze the data, distinguishing normal flows from leaks. This modern approach bypasses traditional, lengthy leak detection methods, ensuring faster, cost-effective results. This breakthrough not only preserves water but also equips consumers with timely, cost-saving solutions.

IoT Leak Sensor: At the frontline of detection are the IoT leak sensors, designed to pick up the distinct sounds of water leaks. These sensors act as vigilant listeners, continuously monitoring for any anomalies that may indicate a potential leak.

Figure 10. IoT Leak Sensor Example

Mobile Application: By integrating AI, the mobile application serves as an invaluable tool for consumers. Once the IoT leak sensor picks up potential leak sounds, the data is relayed to the user's mobile phone. Here, AI algorithms analyze the data, determining if a leak is present. This empowers customers to detect leaks independently, without always relying on professional services, ensuring timely detection and cost savings.

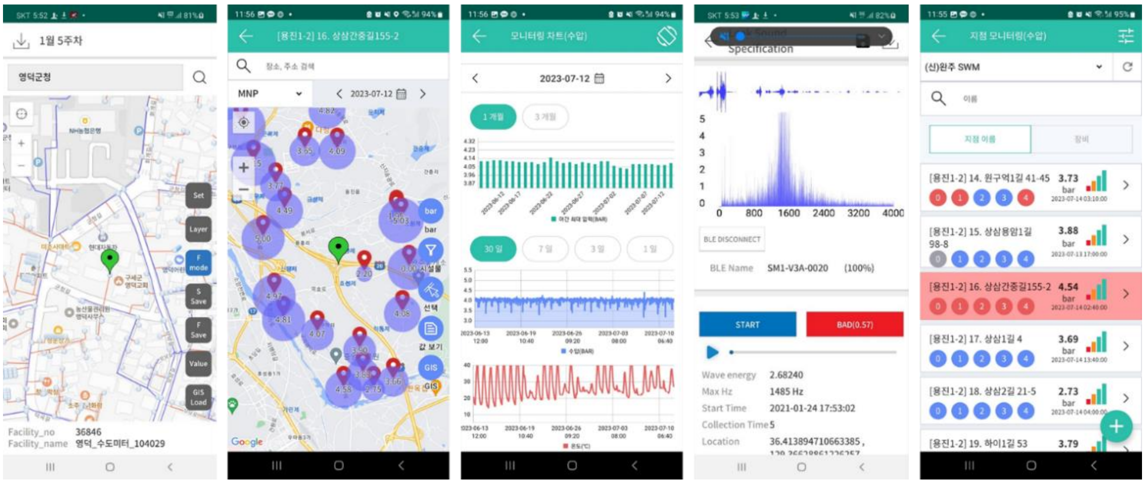

Figure 11. Screen Example of Mobile Application for Leak Detection

Web Analysis System: This online platform provides a comprehensive view of the water pressure data collected remotely. Using sophisticated algorithms, it examines patterns and anomalies, particularly focusing on the Maximum Night Pressure (MNP) – the pressure observed between 3 am and 5 am. Any significant variations during this period, when water usage is typically at its lowest, can indicate potential leaks in the system.

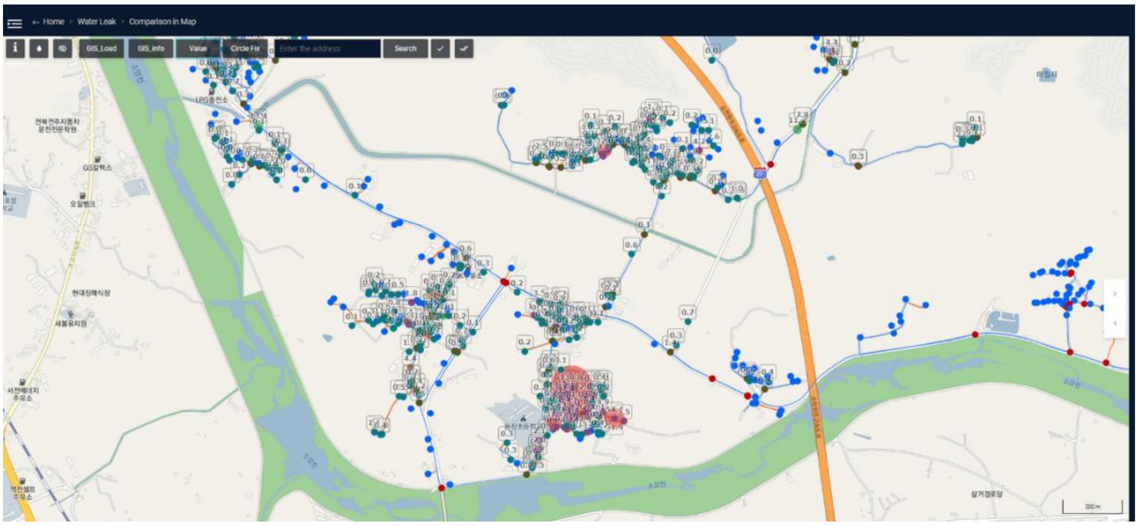

Figure 12. Screen Example of Web Software for Leak Detection

3) Pressure Control

Controlling pressure in DMA is essential for minimizing water losses, prolonging the lifespan of the infrastructure, and ensuring consistent water supply to consumers. Pressure Relief Valves (PRVs) play a crucial role in this aspect within District Metered Areas (DMAs). There are mainly three types of pressure control methods used with PRVs in DMAs: fixed control, time-based control, and water flow-based control:

Fixed Pressure Control: This is the most straightforward method. Here, the PRV is set to maintain a constant downstream pressure regardless of the variation in flow or demand.

Time-Based Pressure Control: As the name suggests, in this method, the PRV adjusts the pressure based on preset schedules. These schedules are typically determined by historical demand patterns. This method allows for more flexibility than fixed control. It can reduce the pressure during low-demand periods, thus conserving water and reducing leakages.

Water Flow-based Pressure Control: In this approach, the PRV adjusts the downstream pressure in real-time based on the actual flow rate. As water demand increases, the pressure is increased and vice versa.

Figure 13. Example of Pressure Relief Valve (PRV)

4) Geographic Information System (GIS) Management

The Geographic Information System (GIS) has become an indispensable tool for water utilities worldwide, especially in the realm of water distribution systems. With its multifaceted capabilities, GIS provides a comprehensive platform that integrates, manages, analyzes, and visualizes data related to water infrastructure.

At its core, GIS excels in mapping the vast and intricate networks of pipes, valves, pumps, and storage facilities. Utilities can visualize their entire water distribution network, understanding spatial relationships and the intricacies of the system.

GIS offers more than just a visual representation. It incorporates valuable metadata about each asset—like installation date, material, diameter, and condition. With this information at their fingertips, utilities can prioritize maintenance activities, anticipate potential issues, and efficiently allocate resources. GIS can be integrated with hydraulic modeling software, helping engineers simulate water flow, pressure variations, and other vital parameters within the network. This aids in identifying potential bottlenecks, optimizing system performance, and planning for future expansions or modifications.

By overlaying real-time sensor data onto the GIS map, utilities can swiftly detect anomalies in flow or pressure that might indicate leaks. This precise geospatial information expedites repair operations, minimizing water loss and service disruptions.

GIS platforms can often be interfaced with customer databases, providing utilities with spatial insights into service coverage, customer complaints, and billing data. Such integration also allows utilities to promptly inform residents about service outages, planned maintenance, or quality issues.

In essence, GIS in water distribution systems is a marriage of technology and strategic management. By harnessing the power of geospatial data and analysis, water utilities are better equipped to serve communities efficiently, sustainably, and resiliently.

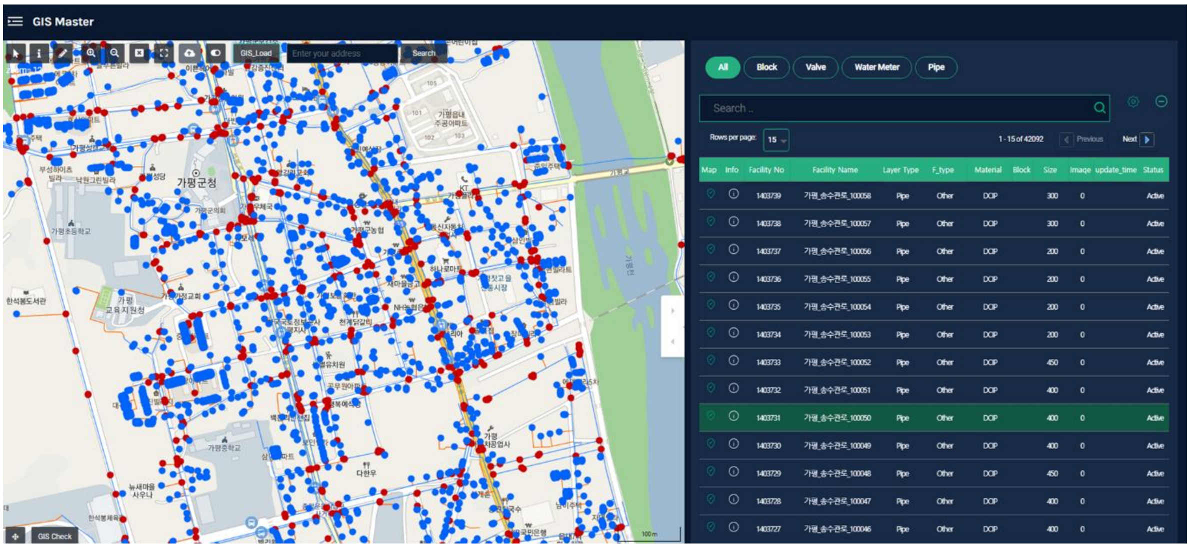

Figure 14. Example Screen of GIS in Intelligent Water Loss Management System

Smart Water Billing System for NRW Management

One of the standout features of this system is its capacity to calculate the Non-Revenue Water (NRW) rate. This is achieved through a dual approach:

Non-Revenue Water refers to the water that has been produced and is lost before it reaches the end customer. Losses can be attributed to a myriad of reasons, from physical losses such as leaks and bursts in the distribution system, overflows at the utility's storage tanks, and even unauthorized usage or theft. There are also apparent losses due to metering inaccuracies where the water is used, but not properly accounted for due to faulty meters or data handling errors.

The significance of NRW cannot be overstated. High levels of NRW indicate inefficiencies in the water distribution system, leading to lost revenue for utilities. It also implies that significant volumes of treated water, which require energy and resources to produce, never serve their intended purpose. This inefficiency puts unnecessary strain on water sources and can exacerbate situations in regions already facing water scarcity.

System Input Volume	Authorized consumption	Billed authorized consumption	① **Billed water exported**	Revenue water
			② **Billed metered consumption**	
			③ **Billed unmetered consumption**	
		Unbilled authorized consumption	④ **Unbilled metered consumption**	**Non-revenue water**
			⑤ **Unbilled unmetered consumption**	
	Water losses	Apparent losses	⑥ **Unauthorized consumption**	
			⑦ **Customer meter inaccuracies and data handling errors**	
		Real losses	⑧ **Leakage on transmission and distribution mains**	
			⑨ **Leakage and overflows at storage tanks**	
			⑩ **Leakage on service connections up to point of customer meter**	

Figure 15. Basic Components of NRW

Instead of relying on manual or sporadic readings, the system benefits from modern data collection methods. On one hand, smartphones can be employed to gather water meter values, enabling more frequent and accurate data inputs. On the other, the integration of Auto Metering Infrastructure (AMI) revolutionizes this process, providing automated and consistent meter readings. This automation reduces human error, ensures timely data collection, and facilitates a more granular understanding of water consumption patterns.

For the pilot project in Bung Khla subdistrict in Bueng Kan Province, Thailand, a mobile method is proposed taking into account local conditions.

Figure 16. Water Meter Reading Method

5. Expected benefits (social, environmental, economic perspective)

The advent of smart water management systems has ushered in a new era of efficiency and sustainability in how we view and utilize one of our planet's most crucial resources: water. This approach to water management promises multifarious benefits that span social, environmental, and economic domains.

1) Social Benefits:

Improved Water Quality & Service: Smart water management enhances the quality of water that reaches households, safeguarding the health of communities and preventing waterborne diseases. With regular monitoring, service interruptions can be minimized, ensuring a constant and reliable supply.

Empowerment of the Layperson: By democratizing access to water data and making systems user-friendly, even those without specialized knowledge can detect leaks or inefficiencies. This empowerment fosters a more engaged and proactive citizenry.

Optimized Operations: With systems that provide real-time feedback and data-driven insights, municipalities and organizations can ensure that water systems operate with minimal disruptions and high efficiency, furthering public trust.

2) Environmental Benefits:

Reduction in Water Loss: Smart systems can pinpoint leaks or areas of inefficiency rapidly, drastically reducing water wastage and ensuring that more water is available for both human use and ecological needs.

Energy Conservation: Efficient water delivery systems, facilitated by smart water management, translate into reduced energy consumption. Less energy is needed to treat and transport water, contributing to a smaller carbon footprint.

Preservation of Natural Habitats: By reducing water wastage, we ensure that natural water sources, like lakes and aquifers, are not depleted at unsustainable rates, safeguarding habitats for countless species.

3) Economic Benefits:

Cost Savings: Reduced water loss translates into savings for water utilities, which can potentially be passed down to consumers. Moreover, energy savings from efficient operations can result in lower costs in the long run.

Job Creation: The design, maintenance, and continuous updating of smart water management systems can stimulate job growth in technology, environmental sciences, and water management sectors.

Infrastructure Longevity: Proactive detection and repair of leaks can extend the life of water infrastructure, deferring the need for costly replacements or overhauls.

Resource Efficiency: With the capability to manage water more efficiently, less capital is wasted on lost water, allowing for funds to be redirected to other crucial areas of development or infrastructure.

In conclusion, smart water management is not just an innovative approach to resource management; it represents a commitment to a more equitable, sustainable, and prosperous future. By intertwining technological advancements with our intrinsic need for water, we lay the foundation for communities that are more resilient, ecosystems that are more vibrant, and economies that are more robust.

Reference

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Water and Sanitation for the Urban Poor, A GUIDE TO NON-REVENUE WATER REDUCTION: HOW TO LIMIT LOSSES, STRENGTHEN COMMERCIAL VIABILITY AND IMPROVE SERVICES

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P-LINK
People's Livelihoods Initiative through water-energy-food Nexus in the MEKONG Region

STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

Proposal on Technology Solution for Viet Nam

1. Introduction

The P-LINK, a project entitled "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. It takes an integrative and multi-sectoral approaches in application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea, and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI), and will enlist the support of other UN agencies.

In the third year of the P-LINK, UNOSSC, STEPI, and four National Mekong Committees agreed on pilot sites and applied technology solutions in Cambodia, Lao PDR, Thailand and Viet Nam that were presented during the 2nd Regional Stakeholder Forum on 31 August 2023. These national pilots are expected to be officially rolled out from 2024 Q1. Against this background, STEPI has prepared a proposal on a technology solution for each country.

The main objective of this proposal is to provide a general introduction to a technology solution for the selected pilot site in Viet Nam. In this regard, the proposal first outlines the pilot site and its challenges. It then presents the basic concept and its main components, a review of available technologies for each component, and proposed candidate technologies. Lastly, it concludes with the expected benefits of the technology solution.

2. Site and Local Challenges

Based on the observations from two field visits and desk analysis, the VNMC and STEPI agreed on Con Linh (Linh Island), Thanh Phu Dong Commune, Giong Trom District, Ben Tre Province as a suitable site for the subsequent pilot implementation. The site met three key criteria: 1) conformity with the objectives and directions of the P-LINK, 2) suitability to the WEF Nexus approach, and 3) impact of the project on the social, environmental, and economic aspects.

The local community in Con Linh has limited access to clean water for domestic use due to saltwater intrusion into the river during the dry season and into the groundwater throughout the year, causing severe freshwater stress to the local community and also negative impacts on agriculture.

In this context, the following possible solution is recommended as one of the possible solutions to mitigate the local challenges faced by the local community in Con Linh:

Innovative technologies for desalination of saline groundwater to provide clean water for domestic use by local residents.

- Desalination techniques from saline groundwater
- System to automatically monitor salinity of saline groundwater

Table 1. Analysis on the proposed pilot site

Site	Con Linh (Linh Island), Thanh Phu Dong Commune, Ben Tre Province
Location	
Main challenges	Main challenge to tackle is to secure access to clean water for domestic use during dry season due to the saltwater intrusion and to ensure sustainable livelihoods for local residents.
Suitability to the WEF Nexus approach	**Water issue:** Limited access to clean water for domestic use due to saltwater intrusion in river during dry season and in groundwater all year round **Food issue:** Damage to agriculture **Energy issue:** No energy shortage issue (access to the national grid) **Others:** Daily livelihood affected

Source: STEPI (2023) P-LINK site selection summary report – Viet Nam

3. Technology Review

3.1 Preliminary survey results to select a site-specific technology for securing water

The Linh Island is the narrow and long island located in the middle of the river, where the residents rely much on rainwater collected from the house roof, but the accessibility of rainwater is constrained to seasonal heterogeneity and a weather condition, which is the reason that they are preparing a bigger or more storage tanks to store rainwater. River water could be a potential water source for them but the quality of river water, especially components such as TDS (Total Dissolved Solids) and probably nitrate and phosphate, is not stable, being influenced by fresh stormwater during the flood season and by intruding seawater during the dry season. Suspended solids (SS), especially very fine clay and mud particles, make it difficult to purify the river water into a fresh drinking water source. These features make it hard to secure a stable freshwater source directly from the river water.

Meanwhile, the groundwater in the Linh island could be a constant water source for this area because the aquifer in this area is expected to be highly productive if it encounters a good sandy porous aquifer and the groundwater quality is very low in SS and moderately constant in TDS. However, the groundwater might occur as a fresh groundwater, limited within a shallow depth and occur as brackish and saline groundwater at moderate to deep depths from the surface. Therefore, the groundwater in this area, whether fresh, fresh or brackish or saline, could not be a direct source of household use water without treatment. The fresh groundwater is easily depleted by long-term pumping activity and therefore the brackish or saline groundwater could be a long-term source of water after proper treatment processes such as desalination.

The desalination system of the brackish or saline groundwater is the proposed technology for this area to ensure constant and stable freshwater resources, even adapting to climate change.

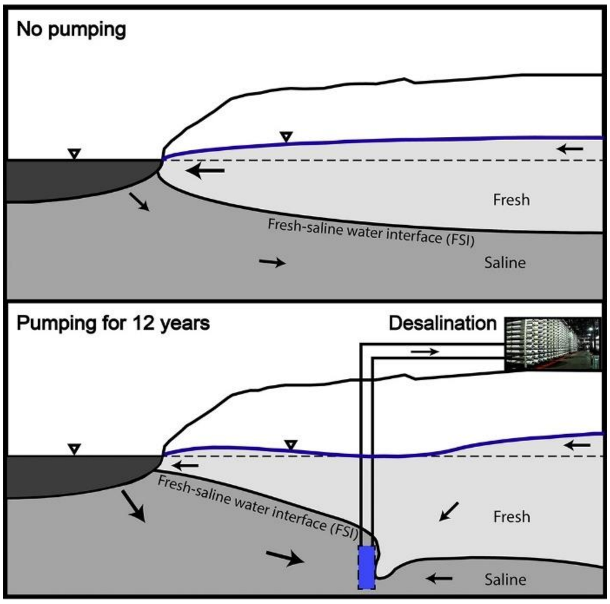


Figure 1. Schematic diagram showing the natural occurrence of fresh groundwater and saline ground water and its interface (a) and the disturbed situation of fresh- and saline groundwater by the desalination of saline groundwater (figure from Stein et al., 2020)

3.2 Technology trend in desalination industry[1]

Starting with the first seawater desalination plant built in Kuwait in 1956, the construction of desalination plants has spread to the Middle East and North Africa, the southern United States, and Australia. Developed to use seawater, an infinite water resource, seawater desalination technology has been expanded in application with the development of materials and process technology, and currently produces 1% of the world's drinking water.

The seawater desalination market grew from USD 10.0 billion in 2006 to USD 14.5 billion in 2018, and is expected to grow to USD 20.26 billion by 2024 at an annual average increase rate of 5.7%. The average global water production cost of seawater desalination plants built before 2016 ranged from USD 1 to 1.3/m^3, but has recently dropped significantly to USD 0.5/m^3. The demand for desalination technology is increasing due to the expansion of water demand due to rising water demand from population growth, increased wastewater reuse, and the reinvestment in

[1] Please note that the contents below are summarized and translated from KISTEP's technology trend brief 2021-07 (KISTEP, 2021).

water-energy infrastructure in developed countries.

With respect to the engineered technology, seawater desalination plants have undergone a paradigm shift from evaporation to reverse osmosis (RO) and have evolved to reduce high energy intensity. Even with the maturity of RO technology, the cost burden compared to the traditional water treatment process is still high, and efforts to develop new technologies are continuing to overcome the high-energy limitations of seawater desalination. In order to advance the RO process, active research is being conducted on the development of separators using new materials such as CNT and graphene, the pre-treatment process in preparation for red tide, module optimization, and the development of separator cleaning technology.

To overcome the energy consumption limitations of the RO process, next generation desalination technologies such as forward osmosis (FO), pressure retarded osmosis (PRO), capacitive deionization (CDI), and membrane distillation (MD) have been developed. Forward osmosis is a membrane separation method that produces fresh water under non-pressurized conditions by filtering salt using a draw solution with high osmotic pressure and using the difference in osmotic pressure between solutions. Pressure retarded osmosis is a technology that uses the osmotic pressure generated by the difference in salinity to turn a turbine to generate electricity. It is a membrane separation method that can produce energy and water (dilution of high salinity raw water). Capacitive deionization process utilizes the principle of a capacitor that temporarily stores charge in a conductor and adsorbs ions to an activated carbon electrode to separate ionic pollutants and water. Membrane distillation is a method of producing fresh water by condensation after passing only steam through a hydrophobic microfiltration membrane using the vapor pressure of the raw water.

Table 2 Summary of next-generation desalination technologies

	Advantages	Challenges	Promising application area
FO	Low energy cost high removal rate	reverse diffusion of draw solution recovery of draw solution	Concentration and dilution
PRO	Using osmotic pressure as renewable energy high removal rate	Energy production efficiency PRO membrane	Energy recovery from highly concentrated solutions
CDI	Low energy cost High removal·recovery rate	Low removal rates for highly concentrated solutions	Low concentration conditions small desalination process
MD	Applicability to highly concentrated solutions	Membrane wetting Low removal rate for volatiles	High concentration process

Recently, new attempts at desalination plants have emerged in accordance with the diversification of water sources and energy mixes to adapt to climate change. around the world. Mixing seawater with wastewater to lower the concentration of ionic compounds and using renewable energy such as solar power to reduce carbon emissions are good examples.

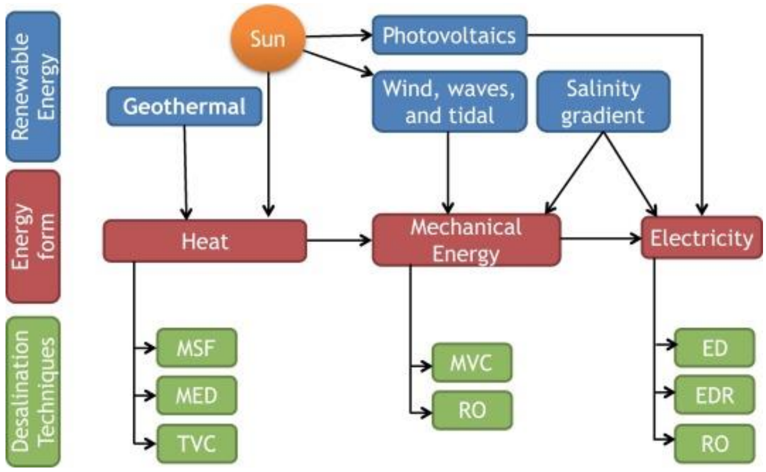


Figure 2. Possible applications of renewable energy sources in the different desalination techniques (Abdelkareem et al., 2018)

On the other hand, as the regulations on the concentrated water (brine), which is inevitably generated in seawater desalination plants, are tightened, the demand for concentrated water management technology is increasing. Concentrated water (brine) from seawater desalination plants contains high concentrations of salt and injected chemicals during pre-treatment, which may cause problems such as deterioration of marine water quality and disturbance of marine ecosystems. Countries around the world are making standards for regulating concentrated water and these regulations are gradually being tightened. Concentrated water management technology includes a method of diluting and discharging concentrated water, an enrichment technology that minimizes the discharge of concentrated water, and a technology that recovers valuable resources from concentrated water. Dilution methods include mixing with wastewater from a nearby sewage treatment plant or spraying concentrated water at a location far from the shore in order to meet the concentration water regulation proposed by the degree of increase in salinity around the outlet. To minimize the generation of concentrated water in desalination plants, the development of Zero-Liquid Discharge (ZLD) and high-concentration enrichment process technology is being promoted. A technology to recover energy and valuable resources from high-concentration wastewater is also being developed. The RO-PRO process for recovering energy from RO concentrated water and the technology for recovering valuable resources such as magnesium, calcium, sodium chloride, bromine, and lithium are actively progressing.

4. Proposed technology: WEF-nexusing desalination system of saline groundwater

The proposed desalination system of saline or brackish groundwater consists of a pumping well to extract saline (or brackish) groundwater from a specific productive aquifer, a modular desalination system, a solar energy system, and a brine reuse system. The solar energy system can be adopted or not depending on the socio-economic conditions of the local environment at this time, however it is highly recommended to use the renewable energy system for future. The brine reuse system mixes the concentrated brine from the desalination plant with a fresh river water at a proper ratio which will be decided for the mixture solution to have a suitable concentration of TDS for shrimp farming. The whole desalination system (Water component) with solar energy system (Energy component) and Brine reuse system in shrimp farming (Food component) is termed as WEF-nexusing desalination system in this report.

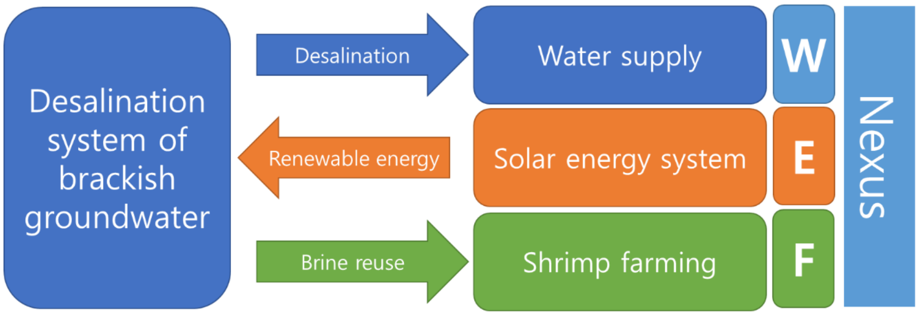


Figure 3. Conceptualized configuration of WEF-nexusing desalination system

4.1 Construction of Pumping well for saline groundwater

4.1.1 Generalized drilling of a water well and well design

Drilling a water wellbore involves the process of creating a hole in the ground to access and extract water and below is a generalized step for drilling of a water well. Drilling a water well is a complex process that requires specialized knowledge and equipment. It's crucial to engage professional well drillers with experience in the specific geological conditions of the area to ensure a successful and safe water well installation.

a. **Site Selection and Preparation**:

- Identify a suitable location for the well based on geological surveys, hydrogeological information, and local regulations.
- Clear the drilling site of any obstructions and ensure accessibility for drilling equipment.

b. **Drilling Rig Setup**:

- Bring in the drilling rig and set it up at the designated location. The type of rig used depends on the well's depth and the geological conditions.
- Make sure the rig is stable and properly anchored to prevent accidents during drilling.

c. **Drilling the Hole**:

- Begin drilling the wellbore using a drill bit attached to the drill string. The drill string is a series of connected drill pipes that rotate the drill bit to grind through the rock formations.
- As the well is drilled, periodically add sections of drill pipe to reach greater depths.

d. **Casing Installation**:

- As the wellbore deepens, install steel or PVC casings to reinforce and protect the hole from collapsing.
- The casing is cemented in place to create a barrier between the well and the surrounding formations, preventing contamination.

e. **Drilling Progress and Monitoring**:

- Monitor the drilling progress and geological formations encountered to assess potential water-bearing zones.
- Continue drilling until the desired depth or a suitable aquifer is reached.

f. **Well Development**:

- After reaching the desired depth, the well is developed to improve water flow and remove drilling debris, mud, and fine particles. This process can involve surging, jetting, or other techniques.

g. **Installation of Well Screen and Gravel Pack (If required)**:

- In aquifers with sandy or loose formations, a well screen and gravel pack may be installed to prevent sand and debris from entering the well while allowing water to flow through.
- This allows the water to be filtered of unwanted materials before entering the well and pumping zone.

h. **Well Cap and Seal**:

- The well is typically cased from the surface down into the smaller hole with a casing that is the same diameter as that hole. The annular space between the large bore hole and the smaller casing is filled with bentonite clay, concrete, or other sealant material. This creates an impermeable seal from the surface to the next confining layer that keeps contaminants from traveling down the outer sidewalls of the casing or borehole and into the aquifer. In addition, wells are typically capped with either an engineered well cap or seal that vents air through a screen into the well.

i. **Pump Installation and Testing**:

- Install an appropriate pump in the well to lift water to the surface.
- Conduct pump testing to determine the well's yield and assess its performance.

j. **Water Quality Testing**:

- Regularly test the water quality from the well to ensure it meets health and safety standards.

k. **Monitoring equipment for water level**

- In many cases, a rural farm well is not easily accessible for monitoring and for conducting regular preventative maintenance.
- Hydrant would facilitate the performance of periodic pump tests to collect specific capacity data and water samples, which are necessary data to forewarn of any potential problems.
- Another simple design adaptation is to install an access tube that extends from just above the well intake area to the top of the well casing. The access tube could also have an appropriate fitting to allow connection of an injection pump as well as an air compressor. For preventative well maintenance, an access tube will allow treatment chemicals to be introduced directly into the well intake area, and could permit air-lift pumping to disrupt and remove plugging material from the well. A water level sounder could also be lowered down this access tube to monitor water levels in the well.

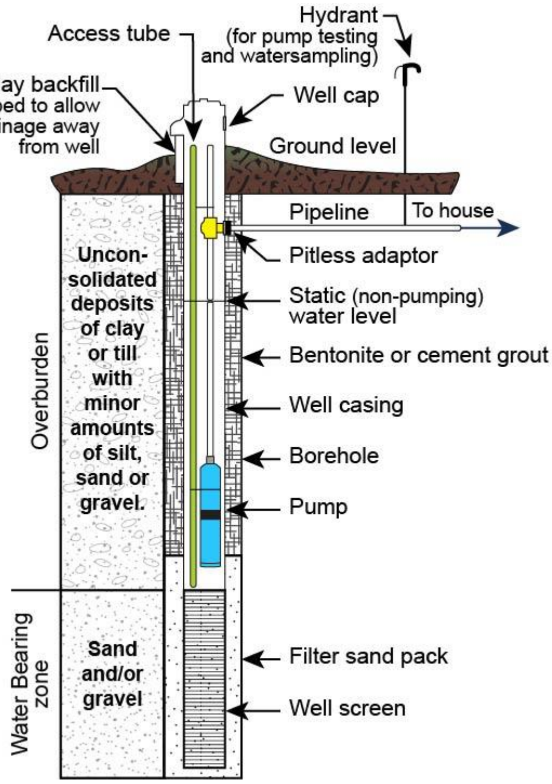


Figure 4. Well design for pumping of saline groundwater. (source: https://agriculture.canada.ca/en/environment/wells-and-groundwater/well-design-and-wellhead-protection)

l. **Wellhead protection**

- A wellhead is the physical structure of the well above the ground and wellhead protection is simply the protection of the area surrounding the wellhead from contaminants that are likely to move toward or reach the well.
- Pollutants spilled, or dumped on the ground, or pollutants seeping from a point source can enter the ground and eventually make their way into a well, and risk contaminating the well water and the aquifer source. Pollutants can include:
- Farm, household or industrial chemical storage; storage and spreading of road salt; use and spilling of fertilizers and pesticides; accidental spill of hazardous materials; septic tanks; animal manure and wastes; contaminants from rodents, insects or wildlife; fuel storage
- The contamination can result in an unsafe and/or unhealthy water source that may have to be closed down in extreme cases, or require additional treatment in order to be used. It can be costly and time consuming to clean up polluted groundwater or find new sources of clean water.

4.1.2 Expected productive aquifer depth

A productive aquifer is expected to be encountered at least once within the depth of 150m below the ground surface based on the literature such as the cross-sectional geological data by Nguyen et al (2004), but due to the heterogeneity, it is strongly recommended to start core logging before drilling a big water production well.

Groundwater quality is expected to be brackish to saline groundwater property due to long-term mixing of flooded freshwater and recharged fresh groundwater and intruding seawater.

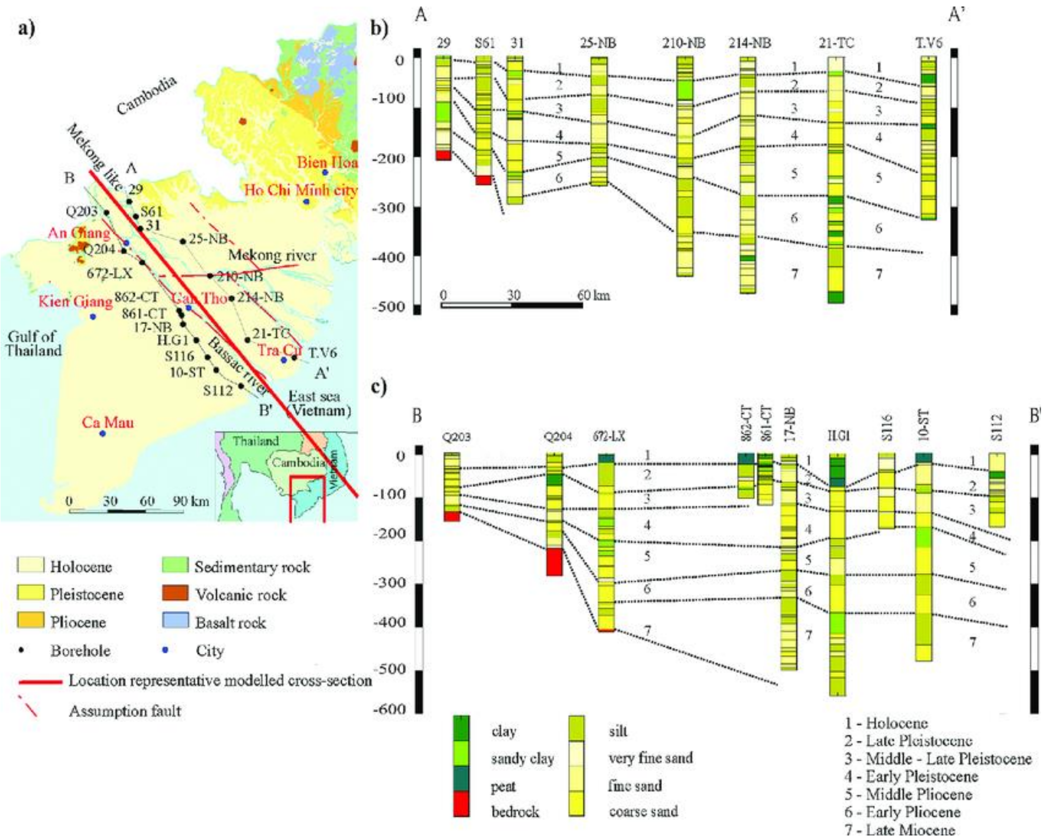


Figure 5. The setting and geological features of the Vietnamese Mekong Delta with the locations of the cross-sections AA' and BB'; sedimentary rocks in the northern boundary are sandstone and claystone, and (b–c) two schematized NW-SE hydrogeological cross-sections of the MKD. (Nguyen et al., 2004 cited in Pham et al., 2019)

4.2 Modular desalination system

The basic concept of a desalination system for saline or brackish groundwater involves the process of removing salt and other impurities from saline water such as seawater or saline groundwater, making it suitable for various purposes, including drinking, irrigation, and industrial use. Desalination is particularly crucial in regions where freshwater sources are scarce, and groundwater with high salt content is more readily available.

4.2.1 General types of desalination methods

Desalination technology is largely divided into evaporation, membrane filtration, and adsorption depending on the pollutant removal/separation mechanism.

a. Evaporation method

This method uses phase change, and it is a technology to obtain fresh water by applying thermal energy to evaporate water, leaving salt and condensing the water vapor. Multi stage flash (MSF), and Multi effect distillation (MED) etc. belong to this method. In the method of Multi-Stage Flash Distillation (MSF), saline water is heated under low pressure, causing it to evaporate. The resulting vapor is then condensed to produce fresh water. MSF is energy-intensive but has been widely used in large-scale desalination plants, particularly in the Middle East. Multi-Effect Distillation (MED) is similar to MSF but involves a series of evaporation and condensation stages.

The evaporated water from one stage serves as the heating source for the subsequent stage, maximizing energy efficiency. MED can operate at lower temperatures and pressures than MSF, making it suitable for waste heat or solar energy integration.

b. Membrane filtration

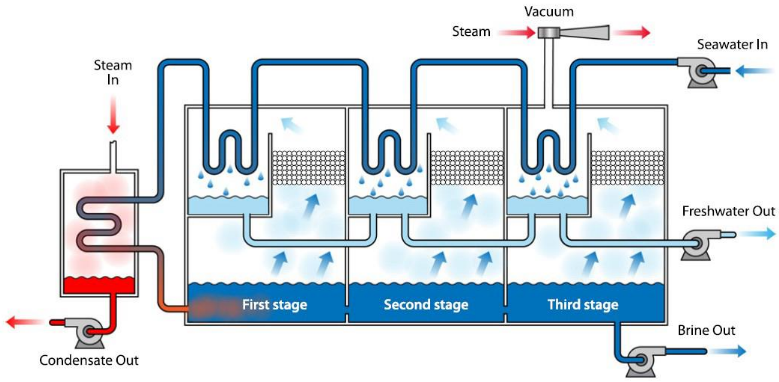
This method is a technology that produces water by applying a pressure higher than osmotic pressure to brine in which contaminants are dissolved, using a separation membrane with micropores at a level that allows only water molecules to pass through. Nanofiltration (NF) and Reverse osmosis (RO) etc. belong to this method. Reverse osmosis is the most widely used desalination technology. It involves applying high pressure to saline water to force it through a semi-permeable membrane, which allows water molecules to pass through while rejecting salts and other impurities. Reverse osmosis is energy-intensive but highly effective in producing fresh water.

c. Adsorption

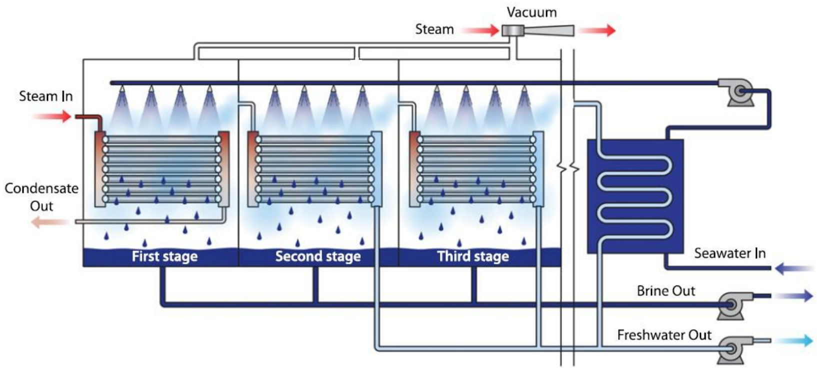
This method uses electrostatic attraction to separate water and contaminants. It includes Ion exchanger (IX), Capacitive deionization (CDI), etc. In electrodialysis (ED), an ion-exchange membrane is placed between two electrode compartments, dividing the brackish water into two streams. When an electric field is applied across the electrodes and the ion-exchange membrane, the dissolved salts in the brackish water are separated into positively charged ions (cations) and negatively charged ions (anions). The ions are then selectively drawn through the ion-exchange membrane, leaving the freshwater stream with a reduced salt concentration.

d. Solar desalination

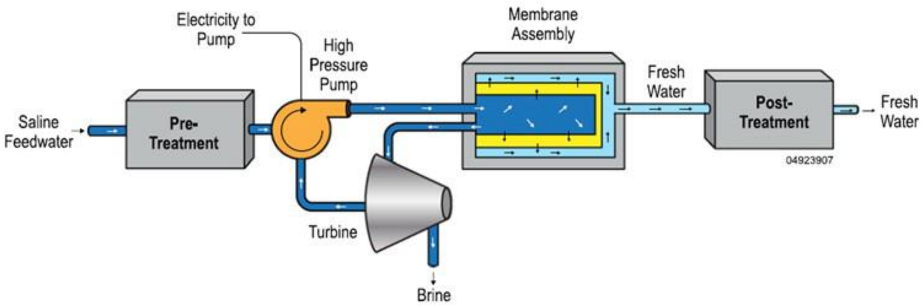
Solar desalination technologies use solar energy to drive the desalination process. These include solar stills, solar-powered RO, and solar-driven humidification-dehumidification systems. Solar desalination offers a sustainable and environmentally friendly approach, particularly in regions with abundant sunlight.



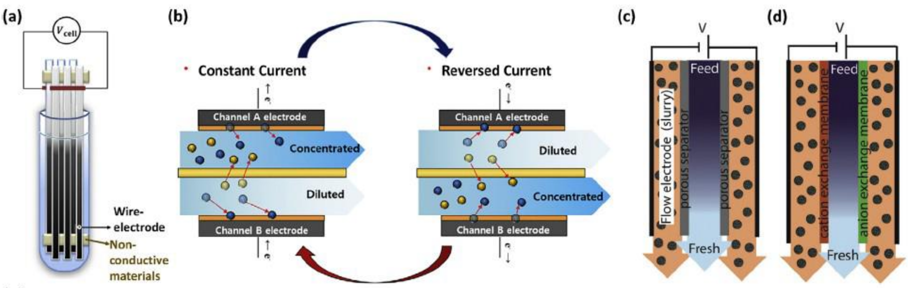
(a) MSF (Multi Stage Flash)



(b) MED (Multi Effect Distillation)



(c) Reverse osmosis



(d) CDI (Capacitive Deionization)

Figure 6. A schematic diagram of the typical desalination processes (KISTEP, 2021).

4.2.2 Proposed desalination system for the Linh Island

The proposed desalination system of saline groundwater is consisted of backwashing filter, membrane filter, antiscalant/disinfectant, RO system, and storage tank.

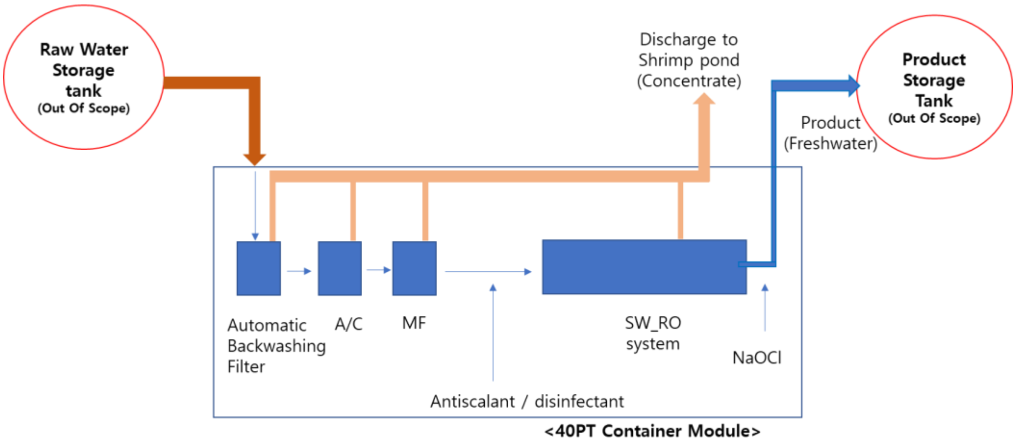


Figure 7. A conceptual configuration for the proposed desalination system

a

b

c

d

e

f

Figure 8. Example of a modular desalination system

The proposed desalination process: Reverse Osmosis (RO)

- Reverse osmosis is one of the most widely used desalination processes for brackish groundwater. It involves using a semi-permeable membrane to remove dissolved salts and impurities from the water.
- The process works by applying pressure to the saline water on one side of the membrane, forcing water molecules to pass through the membrane while leaving behind the dissolved salts and contaminants.
- The purified water that passes through the membrane is collected as freshwater, while the concentrated brine containing the removed salts is discharged and properly managed.
- Reverse osmosis is energy-intensive but highly effective in producing freshwater.

SWRO is an energy-intensive process due to the high pressures required to overcome the osmotic pressure and the need to pump large volumes of seawater. However, advancements in RO technology and energy recovery devices have significantly improved energy efficiency in SWRO plants over the years. SWRO has been widely adopted in coastal regions around the world where seawater is readily available as a water source but requires desalination to meet the freshwater demands of communities, industries, and agriculture. The SWRO process involves several key steps:

a. Intake: Seawater is collected from the ocean through intake structures, typically located offshore. The intake system prevents the entry of marine organisms and debris into the desalination plant.

b. Pretreatment: Seawater undergoes pretreatment to remove suspended solids, such as sand, silt, and larger particles. This is done to protect the RO membranes from fouling and clogging.

c. High-Pressure Pumping: The pretreated seawater is pressurized using high-pressure pumps to overcome the osmotic pressure and force it through the RO membranes.

d. Reverse Osmosis Membranes: The pressurized seawater is then passed through a series of semi-permeable membranes in the RO unit. These membranes allow water molecules to pass through while rejecting salts, minerals, and other impurities. The separated freshwater is collected, while the concentrated brine, containing the rejected salts, is discharged.

e. Post-Treatment: The produced freshwater from the RO process often undergoes post-treatment to adjust its pH, re-mineralize it to improve taste and quality, and disinfect it before distribution for various uses, such as drinking water or irrigation.

4.3 Solar energy system (optional)

Reverse osmosis process is an energy-intensive process that would be used primarily to desalinate saline (or brackish) groundwater. The amount of electricity per ton varies greatly depending on the salinity concentration of the source water, so the issue of power supply to operate the proposed system is important.

A solar energy system, also known as a photovoltaic (PV) system, is a renewable energy system that converts sunlight into electricity. While there are initial costs associated with installing a solar energy system, the long-term benefits and positive impact on the environment make it an increasingly popular choice for both residential and commercial applications. As technology advances and costs continue to fall, solar energy is becoming more accessible and widespread as a clean energy solution. There are off-grid solar systems and on-grid solar systems, but on-grid solar systems are recommended for the proposed site because the area is connected to and supplied by the national electricity grid.

The on-grid solar energy system consists of various parts such as the solar module with mounting, inverter, batteries (optional), fuse box, electricity meter.

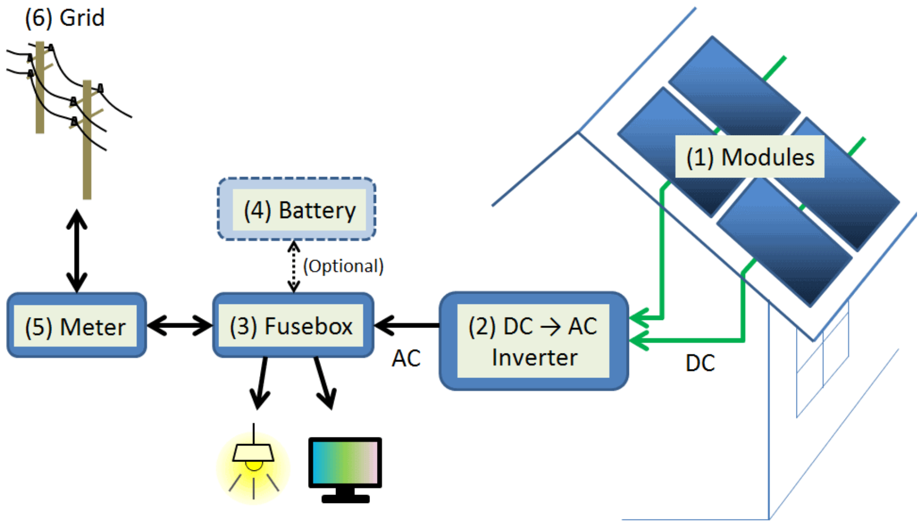


Figure 9. Block diagram of on-grid solar energy system for stable power supply (Source: https://www.literoflightusa.org/solar-panel-diagrams/)

Solar module with mounting

Solar modules are sealed units that contain either sixty or seventy-two solar cells. These are carefully mounted and sealed to protect them from the elements and allow them to produce electricity for around twenty-five years. Several solar modules are connected together to form a complete solar array. the mounting of a solar array is simply the aluminum racking on which the solar panels are mounted. On rooftop solar installations, this mounting usually includes a space between the roof tiles and the panels as a temperature control to keep the panels cool.

Inverter

Solar panels generate direct current (DC) electricity, but general desalination systems use alternating current (AC) electricity. The inverter is where the DC electricity is converted into AC electricity, making it compatible with the grid power supply and suitable for use in most household appliances.

Batteries for hybrid solar system

On-grid solar systems often don't include batteries because the solar system is connected to main electricity supply. However, batteries can be added to provide back-up power in the case of a grid outage. Electricity is transferred back and forth through this grid connection, so any excess electricity that is generated is made available to the grid as a whole. In hybrid solar systems, batteries are added to an on-grid connection to provide back-up power in the event of power outages.

Fuse box

The solar systems, like all other domestic electrical systems, have a fuse box. This is a vital safety device where power surges or other problems will trip a fuse, cutting power to the system and keeping it safe.

Electricity meter

Electricity meter is connected to the desalination solar network in on-grid and hybrid solar systems. The meter monitors and records its electricity usage, the difference is that with its solar array connected, the meter will tell when you're giving more electricity into the system than you're using, and the meter will run backwards.

4.4 Brine reuse system for a shrimp aquaculture

The demand for concentrated water management technology is increasing as the regulations on the concentrated water (brine) become more stringent. The brine from saline groundwater desalination plants will contain high concentrations of salt, which can cause problems such as deterioration of marine water quality and disturbance of marine ecosystems if improperly discharged. On the other hand, shrimp aquaculture is one of the most vital sectors in the Mekong Delta of Vietnam in terms of economic wellfare, social aspects, and food security beyond the country's borders. If the brine could be used for the shrimp farming on the island, the whole desalination system with the equipment of solar system and brine reuse system is considered as an eco-friendly system.

The brine reuse system proposed for the Linh Island is going to mix the concentrated brine from the desalination plant with a fresh river water (or slightly brackish river water in dry season) in a proper ratio, which will be decided for the mixed solution to have a suitable concentration of TDS for shrimp farming.

Figure 10. A Shrimp farming pond in the Linh Island

5. Expected benefits (social, environmental, economic perspective)

Social benefit

Sustainable water resources are expected to be secured for the islanders, who currently rely on rainwater for domestic water source through a desalination system of saline groundwater.

Figure 11. Water tank for collection of rainwater from rooftop.

Environmental benefit

The concentrated brine water produced from desalination facilities can be reused by mixing it with river water to supply shrimp farms before discharge. This will result in low environmental impact. The use of renewable energy, such as a solar power system, is expected to reduce carbon dioxide emissions. The combination of seawater desalination, photovoltaic systems and shrimp farming will remain as a good example of a water-energy-food (WEF) nexus.

Economic benefit

The desalination system of saline groundwater is expected to reduce the required size of the water purification plant because it uses a compact modular system without the need for a settlement pond and area for a flocculation process. It could save an operation cost as the saline groundwater in a sandy aquifer could generally have a consistent water quality in terms of chemical composition, especially low turbidity compared to river water, which is a positive factor in operation and maintenance.

The islanders are expected to save the time and cost of buying and delivering bottled water for domestic use. The brine reuse system is expected to help shrimp farmers to grow shrimp with a water of constant salinity throughout the year.

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TRAINING OF TRAINERS WORKSHOP ON

ADVANCING WATER-ENERGY-FOOD NEXUS PILOT IMPLEMENTATION IN THE LOWER MEKONG BASIN

COMPLETION REPORT

October 16-19, 2023 I Mekong River Conference Room

Mekong Institute, Khon Kaen, Thailand

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We are equally thankful to both the MI's in-house resource persons and the external resource persons coming from various countries for sharing their invaluable experiences and expertise with the participants. Lastly, we wish to convey our appreciation to our collaborative partners, including the United Nations Office for South-South Cooperation (UNOSSC), the Science and Technology Policy Institute (STEPI), and the Mekong River Commission Secretariat (MRCS). Without their significant contributions, the success of this workshop would not have been possible.

Sustainable Energy and Environment Department
Mekong Institute
October 2023

ACRONYMS

BDS	Basin Development Strategy
BOD	Board of Directors
LAC	Latin America and the Caribbean
LMB	Lower Mekong Basin
MSIT	Ministry of Science and ICT
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
P-LINK	People's Livelihoods Initiative through Water-Energy-Food Nexus in the Mekong Region
RoK	Republic of Korea
SDGs	Sustainable Development Goals
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SSC	South-South Cooperation
STEPI	Science and Technology Policy Institute
STI	Science, Technology and Innovation
TrC	Triangular Cooperation
UNOSSC	United Nations Office for South-South Cooperation
UNDP	United Nations Development Programme
WEF	Water-Energy-Food

COURSE INTRODUCTION

Introduction

Project Background and Course Information

In September 2021, the UNOSSC, the Republic of Korea's Ministry of Science and ICT (MSIT), and the Mekong River Commission (MRC) jointly launched a project titled "Triangular Cooperation on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus." This project, also referred to as the "RoK-UNOSSC Facility Phase 3" and P-LINK, aims to enhance access to water, food, and energy for vulnerable communities residing in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) by strengthening development approaches and management in these sectors. It employs integrated and multi-sectoral approaches in applying high-demand technologies related to water, energy, and food to improve the livelihoods of the local population, emphasizing South-South and triangular cooperation (SS & TrC) modalities.

This 5-year project is supported by the Republic of Korea's Ministry of Science and ICT (MSIT), and its implementation is led by UNOSSC in collaboration with other institutions, including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI), and the Science and Technology Policy Institute (STEPI) of Korea. The project will also involve the expertise of Korean experts in Science, Technology, and Innovation (STI).

In support of the national pilot implementation, MI, cohosted with other implementing partners, organized the first capacity-building program with the aim of enhancing the selected participants' understanding of national pilot design and indicators. This workshop also equipped participants with advanced skills, regional perspectives, and the professional and personal networks necessary for successful national pilot implementation.

As per the proposed plan, MI announced an online follow-up workshop scheduled for around April 2024, six months after the initial workshop. The online follow-up workshop will serve as a platform for connecting the progress and outcomes of the pilots. Furthermore, it will facilitate discussions aimed at advancing cooperation in the WEF nexus on a sub-regional scale through a multi-stakeholder forum at that level.

Course Contents and Methodologies

During the 3.5-day TOT workshop, participants underwent training in three interconnected modules:

- Module 1: Introduction to WEF Nexus
- Module 2: Introduction to National Pilot Design and Indicators
- Module 3: National Pilot Project Implementation and Management

All training modules and exercises were tailored to the context of the Lower Mekong Basin (LMB), emphasizing practical knowledge and adult learning principles. The program was designed using an "integrated curriculum" approach where competencies were thoughtfully chosen, theory was integrated with skill-based practice, essential knowledge supported skill performance, and various functional competencies (e.g., facilitation, presentation, communication skills) were developed. The program primarily followed a modular training approach, taking participants through three progressive stages: (i) Learn to Do, (ii) Do to Learn, and (iii) Share to Learn.

Course Participants

The training had 17 participants, as illustrated in **Figure 1**, representing the four Lower Mekong countries: Cambodia, Lao PDR, Thailand, and Viet Nam. These participants included representatives from the National Mekong Committee, government officials, and local agencies.

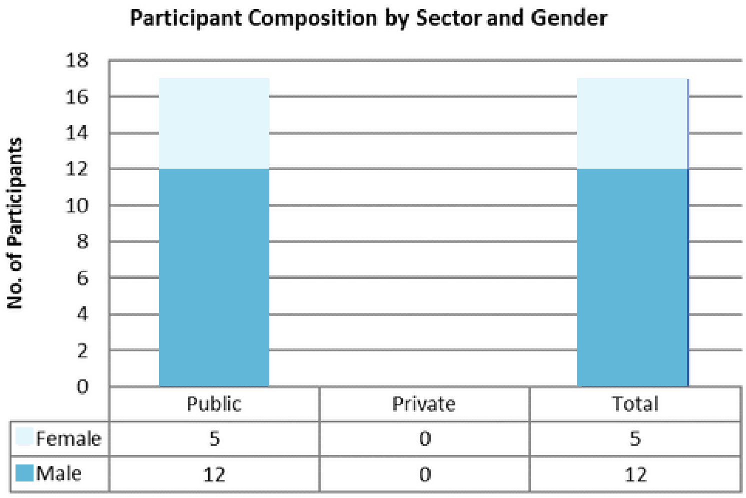
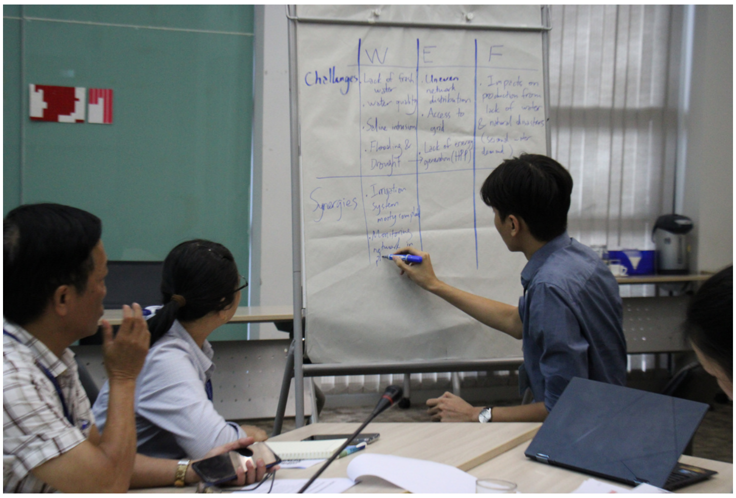


Figure 1. *Participants' Distribution by Sector and Gender*



COURSE ACTIVITIES

Introductory Session

Opening Ceremony

Mr. Suriyan Vichitlekarn, Executive Director of MI, opened the event with a warm welcome and expressed gratitude to all project partners who have been involved since its inception. The primary objectives of the event were to support the implementation of the national pilot and enhance the knowledge of selected participants regarding the national pilot's design and indicators. He also recalled the previous two Regional Consultative Forums and four National Stakeholder Consultative Forums held from September 2022 to August 2023, which aimed to propose the selection of pilot sites in each country and identify technology solutions for each site.

The opening session included a recorded video message from Dr. Xiaojun Grace Wang, Trust Fund Director of UNOSSC. In her speech, she emphasized the importance of the WEF concept for South countries and stressed the need for an integrated cross-sectoral approach to managing critical resources. She also mentioned the key deliverables aimed at developing actionable strategies aligned with MRC's Basin Development Strategy (BDS) 2021-2030 and the UN Sustainable Development Goals (SDGs).

Setting the Context

The first presentation was delivered by Mr. Chakdao Sudsanguan, a project officer of MI. His presentation included two sections: brief profiles of resource persons and an overview of MI facilities and the e-learning system. The second section provided information about participants' stay in Khon Kaen, including essential facilities in the MI building, social activities, travel arrangements outside of training hours, and access to training materials through the MI e-learning platform.

Ms. Yejin Kim, Project Manager of RoK-UNOSSC Facility Phase 3/P-LINK, UNOSSC, then presented the program overview, covering the project's objectives, results framework, implementing structure, and stakeholders. The latter part of her presentation linked back to the milestone of the national consultative process, where the national pilot designs for each country were introduced. She briefly explained the objectives and proposed technological solutions for each country. The following are the project titles for each country, indicating their respective scopes of focus:

- Cambodia: Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng Province
- Lao PDR: Local Flood Early Warning System in Nakio Village in Khammoune Province
- Thailand: Increasing the Efficiency of Tap Water System in Moo (Villages) 1, 2, and 3, Bung Khla Sub-district, Bueng Kan Province
- Viet Nam: Improvement of Livelihoods through the Application of WEF Nexus Approach in the Mekong Delta

After covering the above components, a way forward and further recommendations were discussed in four main areas, including national ownership and accountability in pilot implementation, concerted strategy on pilot sustainability and scalability, reconciling local pilot activities with regional Interventions, and visibility of the project.

As an icebreaker exercise, participants sat in a circle and introduced themselves one by one, stating their name, current position, and organization along with brief responsibilities. To help participants recognize each other, a passing-the-ball game was introduced. The rule was for participants to pass the ball to the person seated next to them, and when the music stopped, they had to identify the name of the person sitting opposite them.

Before starting the first module, all participants were divided into groups to discuss their expectations for the event in terms of learning expectations, interested topics, co-participants, and classroom norms. As part of the Board of Directors (BOD) session, all participants took on the role of a BOD member to ensure a sense of ownership of the event. The BOD team was selected daily in the morning, and at the end of the day, they held a brief meeting with the organizing team to gather feedback about the training approach and identify any necessary adjustments to improve the next day or future events. Each morning, activities such as small games and exercises were held to recap the learnings of the day before as well as energize the participants.

Module 1:

Introduction to Water-Energy-Food (WEF) Nexus

Dr. Atsamon Limsakul, the Director of the Climate Change Adaptation Research Group of the Climate Change and Environmental Research Center, delivered a presentation on the introduction to the WEF Nexus. His presentation emphasized that addressing these issues individually often leads to unintended consequences, and the nexus approach aims to rectify this by embracing an interdisciplinary perspective. This comprehensive approach considers the complex interlinkages among water, energy, and food resources and seeks to understand their interactions, synergies, and trade-offs. Dr. Atsamon then elucidated the core threats to the WEF Nexus, such as the escalating global demand for water, energy, and food driven by factors like population growth, economic development, urbanization, and climate change. These challenges were detailed, including the intensification of the global water cycle, increasing water pollution, and the significant number of people lacking access to safe drinking water. The processes involved in the WEF Nexus were detailed, focusing on consultative processes and multi-stakeholder collaboration. He elucidated the significant influence of the WEF Nexus on the achievement of the SDGs, directly linking to goals related to zero hunger, clean water and sanitation, and affordable and clean energy, as well as indirectly impacting other SDGs. Complex interactions among the WEF targets of the SDGs were explored, highlighting the importance of a shared understanding of objectives and scenarios to achieve concrete agreements on multi-sectorial and multi-scale strategies.

After outlining the key concepts, Dr. Atsamon provided a case study titled "Thai Rice NAMA", a pilot project in Thailand aimed at transforming conventional rice farming into a low-carbon, low-emission approach. This initiative involves the adoption of Sustainable Rice Platform (SRP) Standard/Good Agricultural Practices (GAP++) by farmers to reduce greenhouse gas (GHG) emissions and achieve SRP certification. The project encompasses 100,000 farmer households in irrigated areas of six provinces, with a goal of reducing GHG emissions by 1.73 million tCO2eq over five years. Key mitigation technologies employed include the Low Land Livelihood (LLL) approach, Alternate Wetting and Drying, and Straw and Stubble Management. The project has not only trained numerous farmers but has also significantly reduced GHG emissions, particularly methane (CH4). Valuable lessons have been learned, highlighting the importance of stakeholder collaboration, co-benefits, and alignment with national policies.

Next, Dr. Hwanil Park, Chief Director and Senior Research Fellow of the Division of Global Innovation Strategy Research, STEPI, continued the module with the presentation on the Role of Science, Technology, and Innovation (STI) in Integrated Development. He began by discussing the continuously evolving and interconnected nature of global challenges and highlighted the interrelation of the WEF Nexus with the risk of this nexus measured by the volatility of resource prices, influenced by supply and demand factors as well as environmental, economic, and social conditions. Dr. Park stressed the need for integrated resource management and collaboration to minimize policy and price risks, especially in the context of climate change and its impact on the WEF Nexus. In his conclusion, he emphasized the region-wide benefits of constructing small-scale WEF Nexus demonstrations across the Mekong region, ensuring broad-reaching positive impacts.

After discussing the role of STI, Dr. Park introduced three case studies, selected based on STEPI's criteria, which encompassed the WEF Nexus, Land, and Urban components. For each case, he elucidated the successful factors, identified challenges, and offered implications for P-LINK, allowing participants to gain insights into related contexts.

- Case 1: "Water and Energy for Food (WE4F)," is a 5-year project with the aim of increasing food production sustainability through efficient water and energy usage, providing innovative solutions for WEF Nexus challenges, and promoting climate and environmental resilience.
- Case 2: "Integrated Resource Management in Asian Cities: The Urban Nexus," was executed in two phases, focusing on enhancing the capacity of local and national governments to formulate and implement integrated policies and the sustainable management of natural resources in urban areas.
- Case 3: "Nexus in Korea and Utilization for Latin America and the Caribbean (LAC) Countries" seeks to analyze successful nexus cases in South Korea, investigate existing projects in Latin American and Caribbean countries, and conduct feasibility studies for potential pilot projects. This initiative centers on the application of Korea's water management technology and experience to benefit LAC countries.

Mr. Youngwoo Kim, Environment Advisor from the Nature, Climate and Environment Team, United Nations Development Programme (UNDP), took the floor to present other case studies. His presentation focused on UNDP's ongoing projects and initiatives and its alignment with the WEF Nexus. Two case studies were brought up in his session.

- Case 1: Supported by the Ministry of Agriculture, Food, and Rural Affairs of the Republic of Korea, aimed to enhance the resilience of Cambodia's agriculture sector to climate change. This project included resilient agricultural practices, improvements in the agricultural value chain, and the promotion of solar technologies for water pumping and powering market facilities, benefiting around 7,000 rural farmers.
- Case 2: Focused on the Mekong River Basin and aimed to strengthen climate and disaster resilience in vulnerable regions of Lao PDR and Cambodia through risk and vulnerability assessments. Dr. Kim highlighted the importance of digitalization and how data collection and modeling tools would contribute to the WEF Nexus, emphasizing the role of digitalization in creating new platforms for community empowerment. He also presented the expected project outputs, involving climate and disaster risk assessments, capacity building for climate resilience, identification of adaptation actions, community disaster preparedness, and strengthening Early Warning Systems. He reported on various stakeholder consultations, data collection efforts, and training activities conducted in both Lao PDR and Cambodia.

In conclusion, Dr. Kim highlighted challenges, lessons learned, and enabling factors. Challenges included the need for improved technical knowledge, better coordination across sectors, and comprehensive Early Warning and Forecasting coverage. Lessons learned emphasized integrating data collection and involving a wide range of stakeholders while enabling factors included strong support from relevant government institutions, a broad legal framework, existing technical knowledge, and available funding.

Moving to the last session of the first day, we shifted gears towards a practical exercise-based session. Dr. Atsamon took the leading role in facilitating two interactive exercises designed to deepen participants' understanding of the challenges and interlinkages in the WEF Nexus.

- Exercise 1: Experiences with WEF challenges and interlinkages

The main objective is to identify pressing WEF challenges within the national contexts and understand the complicated web of interdependencies. The participants were arranged into country-group. They engaged in group discussions and collectively summarized their findings, focusing on the major challenges affecting the WEF sectors in their respective nations and exploring the synergies and trade-offs that emerged from their discussions (Please find the outcome in **Annex A**).

- Exercise 2: WEF Nexus Index

A tool designed to measure the interconnectedness of the WEF sectors. Dr. Atsamon provided an overview of the index's conceptual framework, which involved selecting a set of relevant indicators, normalizing, weighting, and aggregating them to create a unitless index. The participants were then guided to explore the WEF Nexus Index website, where they familiarized themselves with its key features. This practical session allowed participants to interact with the index directly, gaining insights into how it quantifies the relationships within the WEF Nexus (Please refer to **Annex B**).

After the preparation, each group appointed a representative to present their insights from both exercises. Comparisons between group results were made, highlighting commonalities and differences. Observations and potential entry points for implementing the WEF Nexus were also discussed.

Module 2:

Introduction to National Pilot Design and Indicators

Mr. Thanawat Wetchapan, Strategy and Partnership Project Assistant of MRCS, delivered a presentation on the National Status and Policies related to the WEF Nexus. His presentation focused on aligning the BDS and SDGs with national policies. He provided brief information on key issues and key alignments of the BDS outputs/outcomes for each national pilot project. He then introduced a small group exercise where each country group identified their national strategies/policies related to the WEF Nexus (Please find the outcome in **Annex C**).

Subsequently, Dr. Dong Un Park, Associate Research Fellow of the Office of Sustainable Innovation Policy Research, STEPI, took the lead in Module 2. He structured the content into three main parts:

1. Pilots:

Dr. Park discussed the technical proposals from the four countries, each presentation covering General Information about each national pilot project, issues and challenges, analysis of technology solutions, national and local demands, target groups, key stakeholders, and follow-ups after the consultative forum.

2. Indicators for Pilots:

He introduced the national pilot indicators designed for the P-LINK project. These indicators aim to monitor the development and progress of National Pilots to showcase improvements in community well-being and WEF security. The methodology behind these indicators involves expert opinions, multi-stakeholder dialogues, data collection, formulation, benchmarking, and result representation, all tailored to reflect national characteristics. The considerations for these indicators include alignment with the BDS, MRC Strategic Plan, UN SDGs, and gender-focused measurements.

The selected indicators reflect local conditions and focus on SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goals, measuring progress from baseline to target and explaining the impact of technology and policy applications within each community, including country-specific technology solutions. Dr. Park addressed challenges, proposed solutions, and expected outcomes and benefits.

3. Discussion & Workshop:
Participants engaged in group activities where they discussed and selected the most suitable indicators for assessing progress within the MRCS scenario. These indicators should be aligned with the broader objectives presented earlier, focusing on three key areas: strengthening WEF security, employment and poverty levels, and the implementation of solutions. To ensure the applicability of these indicators, participants were instructed to consider the SMART criteria. The selected indicators measure aspects like WEF security improvement, damage from flood disasters, job creation, agricultural profit, technology application, and policy adoption. These indicators are vital for evaluating the progress of the community from baseline to target levels and examining the impact of technology and policy applications (Please find the outcome in **Annex D**).

As a concluding session of the second day, Ms. Yejin illustrated the timeline flow of the national pilot project from its initiation to the project launch/pilot rollout. It was noted that the procedure required involvement from local stakeholders, and passing through the formal process in each country may take time. Participants were then asked to complete a form with a particular focus on Situational Analysis (background) and Baseline (target beneficiaries and feasibility requirements) in the national pilot information note template.

Module 3:

National Pilot Project Implementation and Management

Ms. Yejin provided a comprehensive overview of project management principles and key skills to equip participants for the successful implementation and management of their national pilot projects. This session aimed to create a common understanding of project management processes, interact with the Project Management Toolkit, and facilitate customization by including additional relevant topics. Key areas covered included project management methodologies, principles, and enablers. Ms. Yejin emphasized the significance of having clear project structures, well-defined goals, and effective risk management strategies. Furthermore, she highlighted UNDP Social and Environment Standards, mentioning the importance of incorporating principles such as human rights, sustainability, and accountability. She concluded with insights into risk management, financial management, critical path planning, and stakeholder engagement, offering participants a comprehensive foundation for their further steps.

Following Ms. Yejin's session, participants engaged in a Skill Integration Exercise, which was conducted by Ms. Jian Wang, a program manager of MI, and Mr. Chakdao. Participants explored practical aspects of applying key skills to the context of their pilot projects. The exercise was divided into three main components, each with specific details:

1. Stakeholder Engagement: Participants explored the role of stakeholder engagement in the context of their specific projects. The focus was on understanding the significance of actively involving stakeholders, including local communities, government agencies, NGOs, and private sectors, who can impact or be affected by project success.

A structured activity approach involves steps as follows:

1.1. Identify Stakeholders: Determining who could influence the success of the pilot project and who might be affected by it. Participants were encouraged to categorize these stakeholders into groups or clusters.
1.2. Stakeholder Interests: Exploring the interests of each stakeholder group related to the development issues their projects were addressing. Understanding why stakeholders were involved and identifying their dominant interests were crucial.
1.3. Perceived Problems: Clarifying how each stakeholder group perceived the development problems related to the projects.
1.4. Resources: Identifying the resources that each group put forth, either in support or opposition to the development problems.
1.5. Rate Current Collaboration Status: Assessing how favorably stakeholders currently viewed their projects. They evaluated the extent to which stakeholders might support, oppose, or remain neutral towards the projects, rating their collaboration status as Low, Medium, or High.
1.6. Develop Stakeholder Strategy: Proposing strategies to strengthen stakeholders' commitment to the projects. Participants identified their sensitivities and concerns. (Please find the outcome in **Annex E**)

2. Communication Strategies: This component underlined the significance of having a well-designed communication strategy in a national pilot project. Participants were tasked with creating compelling messages tailored to two distinct stakeholder audiences: Local Community and National Agency groups.

2.1. Analysis and Planning: In this first step, participants defined the mission and goals of their communication strategies, identified their target audience, and planned the necessary resources.
2.2. Strategy Design: The second step focused on crafting and tailoring compelling messages. Participants were encouraged to make these messages people-centered, using facts and figures to convey their points.
2.3. Implementation: For the third step, participants identified the best ways to communicate with their target audience, determined the frequency of communication, and used the right tools to deliver their messages effectively.
2.4. Monitor and Evaluate: In the final step, participants were reminded of the importance of continuously monitoring progress and evaluating whether they were meeting their goals and objectives through their communication strategies. (Please find the outcome in **Annex F**)

3. Risk Identification: The final component focused on identifying and understanding potential risks and their impacts on national pilot projects.

3.1. Grouping Risks: Participants were guided to group the identified risks into categories or themes. Four main categories were provided as a guideline for grouping risks: Funding, Technical, Logistical, and Regulatory.
3.2. Assessing Impact and Probability: Each different identified risk was placed in a provided table (Risk Matrix Table). Participants calculated an average score for each risk based on their assessment of its impact and probability, then multiplied the impact and probability to get the scores.
3.3. Prioritization: The combined scores helped prioritize risks. Risks with higher combined scores indicated that they required more immediate action.
3.4. Group Discussion: Participants shared insights and perspectives on the severity of each risk, fostering a collaborative approach to risk management.
3.5. Mitigation Strategy Development: In the final step, participants brainstormed mitigation strategies for the identified risks. These strategies addressed how to minimize the impact and likelihood of each risk. (Please find the outcome in **Annex G**)

At the beginning of the last day, Ms. Yejin continued to guide all participants in working on their pilot project information notes. With their efforts, she and Dr. Hwanil Park facilitated discussions to explore and dig deeper into specific needs and concerns within each respective country. The majority of participants expressed concerns about their complex internal procedures which could potentially hinder the implementation process, making some of them hesitant to provide information as they were not the decision-makers. As for the next step, UNOSSC proposed preparing the initial set of survey questions to collect the required information for item No. 12 (situational analysis) and item No. 13 (baseline/target beneficiaries) (Please refer to **Annex H**). The survey questions will be jointly reviewed by the project team, particularly STEPI. As per the project team's proposal, they have decided to hire local experts in each country, with coordination by UNOSSC and MRCS. These local experts will collect and consolidate input from participants and all relevant stakeholders to further develop a baseline study.

CLOSING CEREMONY

Ms. Maria Theresa Medialdia, Director of Agricultural Development and Commercialization, MI, was invited to the stage to deliver closing remarks on behalf of Mr. Suriyan and present certificates of completion to all participants. During her speech, she reiterated the importance of WEF Nexus integration and emphasized the potential for strengthening regional collaboration. She expressed gratitude to all collaborative partners and participants for their active engagement and conveyed her best wishes for the success of the national pilot projects.

COURSE EVALUATION

The course employed two evaluation methods aimed at assessing the program's achievement against participants' expectations and gathering feedback for future course improvements. Two evaluation methods were utilized in this workshop:

1. Pre and Post-assessments; and
2. After-event evaluation

Pre and Post-Assessment

On the first day, the organizing team conducted a pre-assessment of participants' knowledge of the program content/topics to establish a benchmark of their knowledge and skills. The post-assessment was conducted on the last day of the program to measure the knowledge gained by the participants.

Results of the pre-assessment showed an average score for participants' competency level of 2.54 out of 5, while post-assessment results indicated an average score of 3.31 out of 5 (**Figure 2**). This reflects a 26.32% increase in participants' knowledge and understanding of the WEF Nexus concept, signifying significant knowledge growth on the course topics.

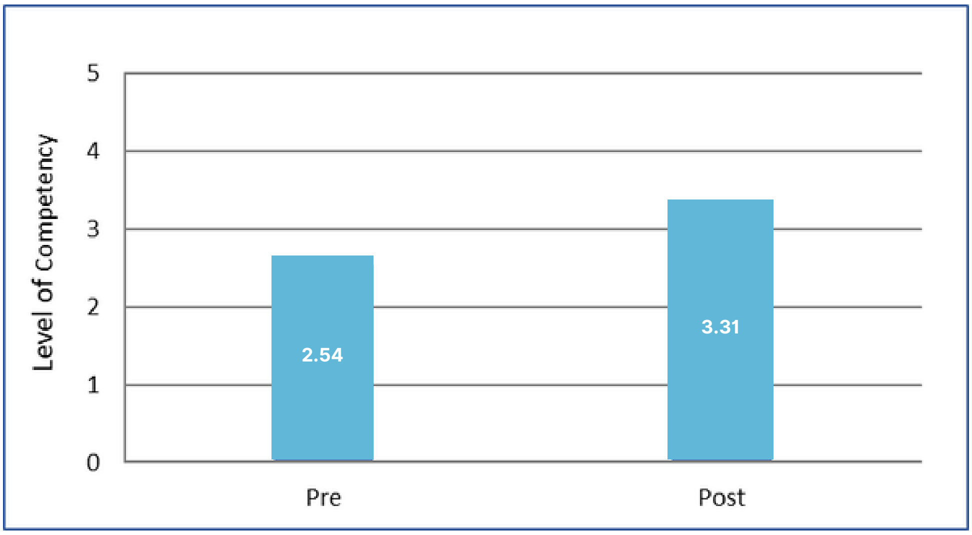


Figure 2. *Participants' Level of Competency from Pre and Post-Assessment*

Regarding their current knowledge of project indicators and project management key skills, it was evident that participants' confidence in utilizing each skill learned during the workshop to develop a practical strategy and plan for their national pilot project increased from 2.53 to 3.2 (**Figure 3**), indicating a 26.48% increase.

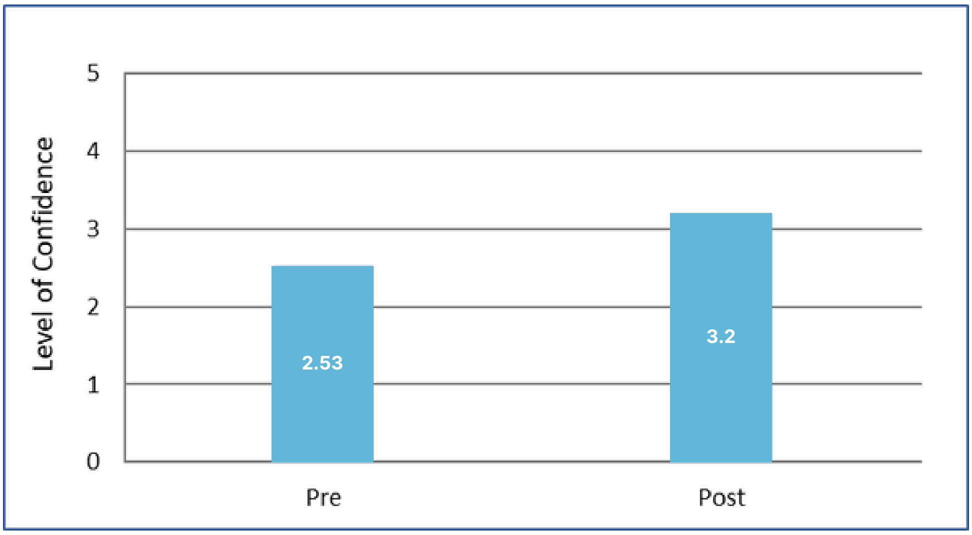


Figure 3. *Participants' Level of Confidence to Apply Key Skills to Their Pilot Projects from Pre and Post-Assessment*

After-event Evaluation

The after-event evaluation was done online through the SurveyMonkey platform. A standardized set of questionnaires was used, including both closed- and open-ended questions on six major indicators: (a) Participants' perceived level of improvement of their knowledge and skills; (b) Level of expectations; (c) level of satisfaction on the training methods used; (d) level of satisfaction on monitoring and evaluation methods used; (e) level of satisfaction of the course's logistic arrangements; and (f) overall level of satisfaction on the training program.

Using five-level Likert scales, the different components were rated with the following weighted average index (WAI) values:

Not Improved/ Met/Satisfied	Slightly Improved/ Met/Satisfied	Moderately Improved/ Met/Satisfied	Mostly Improved/Met/Satisfied	Highly Improved/ Met/Satisfied
1.00	2.00	3.00	4.00	5.00

The following interpretations were used to describe the computed WAI values:

- Not Improved/Satisfied for WAI = 1.00–1.50;
- Slightly Improved/Satisfied for WAI = 1.51–2.50;
- Moderately Improved/Satisfied for WAI = 2.51–3.50;
- Mostly Improved/Satisfied for WAI = 3.51–4.50; and
- Highly Improved/Satisfied for WAI = 4.51–5.00.

Perceived Improvement of Knowledge and Skills, and Content Usefulness

To assess the effectiveness of the course, participants were asked to evaluate whether their knowledge and skills improved after attending the course and whether the training met their expectations. As shown in Table 1, participants reported a significant improvement in their knowledge and skills (WAI = 3.13) after completing the training program. These improvements were moderately significant. When participants were asked about the usefulness of each module in their work/organization, a positive rating was indicated.

Table 1. *Participants' Perception of Knowledge and Skills Gained from the Training Program*

Perception Indicator	WAI	Interpretation
Perceived improvement of knowledge and skills	3.13	Moderately improved
Module 1: Introduction to WEF Nexus	3.47	Neutral
Module 2: Introduction to National Pilot Design and Indicators	3.53	Useful
Module 3: National Pilot Project Implementation and Management	3.64	Useful

Level of Satisfaction with Training Methods Used

This onsite program utilized a combination of interactive learning methods to enhance the learning process while keeping the participants engaged (Table 2). Of these methods, participants gave the highest rating for Interaction with Facilitator/Trainer (WAI = 4.13). Participants were also mostly satisfied with the lectures and presentations (WAI = 3.87), class activities (WAI = 4.00), assignments (WAI = 4.07), and other participants' presentations (WAI = 4.00).

Table 2. *Participants' Level of Satisfaction on Training Methods Used*

Training Method	WAI	Interpretation
Lectures and presentations	3.87	Mostly satisfied
Interaction with Facilitators/Trainers	4.13	Mostly satisfied
Class Activities	4.00	Mostly satisfied
Assignments	4.07	Mostly satisfied
Participants' Presentations	4.00	Mostly satisfied

Level of Satisfaction with Logistic Arrangements

Participants were also asked to rate their level of satisfaction towards the services provided by MI staff members on logistic facilities (Table 4). Among the identified criteria, support by MI training staff (WAI = 4.17) received the highest ratings.

Table 3. *Participants' Level of Satisfaction on Logistic Arrangements*

Logistic Facilities	WAI	Interpretation
Supports by MI Training Staff	4.17	Mostly satisfied
Transportation Arrangement	4.07	Mostly satisfied
Accommodation	4.00	Mostly satisfied
Instruction during the Course	3.87	Mostly satisfied
Training Facilities	3.87	Mostly satisfied

Overall Level of Satisfaction

Based on the results, the average rating for participants' overall level of satisfaction with the training program is 3.67 (mostly satisfied), with the majority of participants giving a rating of moderately satisfied (53.33 percent).

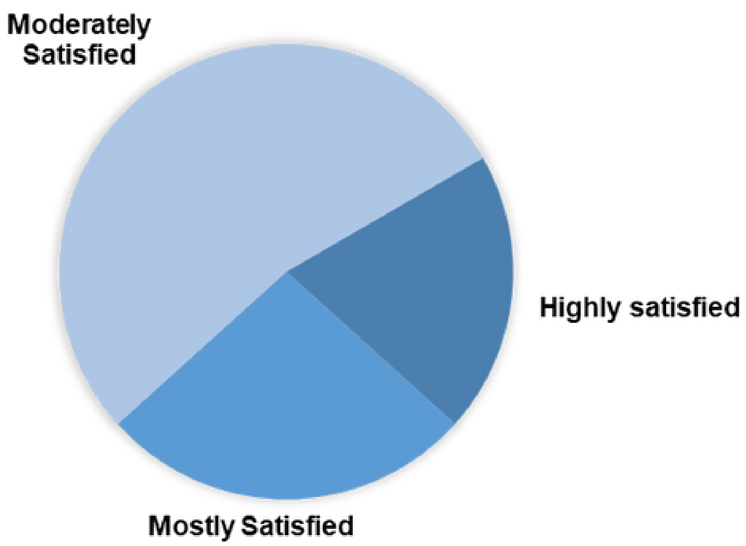


Figure 4. *Participants' Overall Level of Satisfaction*

ANNEXES

Annex A: Experiences with WEF challenges and interlinkages

Annex B: WEF Nexus Index

Annex C: Identifying National Strategies/Policies related to WEF

Annex D: Applicability of National Pilot Indicators

Annex E: Stakeholder Engagement Analysis

Annex F: Developing Communication Strategies

Annex G: Project Risk Matrix and Mitigation Strategy Development

Annex H: National Pilot Information Note Template

Annex I: Directory

Annex J: Program Schedule

ANNEXES

Annex A: Experiences with WEF challenges and interlinkages

Country	Water Challenges	Energy Challenges	Food Challenges
Cambodia	• Lack of irrigation system • Lack clean water • Water pollution • Ground water resources (No mean)	• Electricity shortage • Price is high (electricity)	• Food insecurity • Low productivity technical is limited (traditional method) • Agricultural inputs price is high • Climate change
Lao PDR	Water insecurity	Limited access to energy	Food insecurity
Thailand	• Water shortage • Flood & draglift • Water legalities • clean water	• Access to elasticity • price	• Production • Food scarcity
Viet Nam	• Lack of fresh water • Water quality • Saline intrusion • Flooding drought • Upstream dew	• Uneven network distribution • Access to grid • Lack of energy generation (HPP)	• Impact on production from lack of water & natured disasters (seasoned water demand) • upstream dew (Fisher)

Annex B: WEF Nexus Index

Year	Country	Water	Energy	Food	Total
2019	Cambodia	63.3%	46.0%	48.1%	51.5%
	Lao PDR	71.7%	N/A	49.5%	60.6%
	Thailand	77.2%	52.0%	56.6%	61.9%
	Viet Nam	64.1%	65.5%	60.8%	63.5%
2020	Cambodia	67.4%	57.1%	51%	56.8%
	Lao PDR	71.3%	N/A	55.9%	63.6%
	Thailand	79.2%	51.7%	57.1%	62.6%
	Viet Nam	66.2%	65.2%	66.1%	65.8%
2021	Cambodia	64.1%	57.4%	57%	59.5%
	Lao PDR	70.0%	N/A	59.9%	64.9%
	Thailand	70.5%	53.1%	56.9%	60.2%
	Viet Nam	70.1%	64.5%	66.7%	67.1%
2022	Cambodia	63.6%	54.8%	60.0%	59.5%
	Lao PDR	67.8%	N/A	62.6%	65.2%
	Thailand	59.5%	53.1%	55.5%	56.0%
	Viet Nam	70.3%	N/A	67.7%	69.0%

Annex C: Identifying National Strategies/Policies related to WEF

Country	National Strategies/Policies related to water	National Strategies/Policies related energy	National Strategies/Policies related food
Cambodia	Water resource strategy development plan	• National agricultural development policy • Agricultural sector master plan (2030) (2022-2030) • CCPAD (2021-2030)	
Lao PDR	Monroe vision to ward 2BO Natural resources and Environment Strategy 10 year 2016-2025	Power Development plan in Laos PDR National power development strategy (NPDS) • Develop all Hydropower potential. • Implement the policy sustainable Hydropower development.	Ninth(9th) Agriculture, Forestry and Rural Development plan (2021-2025)
Thailand	• WG standard (PCD) • 20th years (19th) national strategy • 20 years master plan on water resource mange (Consecration and restoration of water ecosystem)	• National energy plan Nation • Renewable Energy	• 20-year national strategy • Strategic framework for (1st strategy-food security)
Viet Nam	Nat strategy for rural dean water & sanitation to 2030	National strategy on energy development to 2030	Decree on National food security to 2030

Annex D: Applicability of National Pilot Indicators

Country	Objective to measure	What to measure	Applicable Indicators	How to measure
Cambodia	1. Strengthened WEF Security	1. Improvement of WEF consumption and production 2. Damage from flood disaster per year	1. Quantity of Water Consumption/Proportion of Household accessible to clean water, 2. Proportion of Renewable Clean Water, 3. Proportions of renewable energy of total electricity, 4. agricultural productivity	1. Baseline and endline comparation 2. Project team and consultant
	2. Employment and Poverty (income level)	1. Jobs created 2. Agricultural profit	Jobs created 1. Employment on Facility installed and/or related, 2. Women's employment *3. Reduction of poverty rate by %?* *Agricultural profit* 1. Income from agriculture per annual work unit, 2. Number of agriculture products for sale	1. Baseline and endline comparation 2. Project team and consultant
	3. Developing Solutions	1. Technology application 2. Policy adoption	Technology application 1. Facility installed and operated 2. Technology knowledge shared and transferred Policy adoption 1. WEF nexus Policy established by central or local government	1. Baseline and endline comparation 2. Project team and consultant

Country	Objective to measure	What to measure	Applicable Indicators	How to measure
Lao PDR	1. Strengthened WEF Security	1. Improvement of WEF consumption and production 2. Damage from flood disaster per year	Improvement of WEF consumption and production 1. Quantity of Water Consumption/Proportion of Household accessible to clean water 2. Agricultural productivity, 3. Women's labor input on WEF production Damage from flood disaster per year 1. Number of death and injury, 2. Loss of livestock, 3. Property loss	1. National, Provincial, District,Village statistics and databaseby official. (MONRE, MAF) 2. Lao Women's Union (atprovincial unit)
	2. Employment and Poverty (income level)	1. Jobs created 2. Agricultural profit	Jobs created 1. Employment on Facility installed and/or related, 2. Women's employment Agricultural profit 1. Income from agriculture per annual work unit, 2. Number of agriculture products for sale	Jobs created 1. National, Provincial, District, Village statistics and database by official. (MLSW) 2. Lao Women's Union (at provincial unit) Agricultural profit 1. National, Provincial, District, Village statistics and database by official. . (MAF: PAFO and DAFO)
	3. Developing Solutions	1. Technology application 2. Policy adoption	Technology application 1. Facility installed and operated 2. Technology knowledge shared and transferred Policy adoption 2. WEF nexus Policy established by central or local government	National, Provincial, District, Village statistics and database by official. (MONRE, MEM, MAF)

Country	Objective to measure	What to measure	Applicable Indicators	How to measure
Thailand	1. Strengthened WEF Security	1. Improvement of WEF consumption and production 2. Damage from flood disaster per year	1 Quantity of Water Consumption/Proportion of Household accessible to clean water 2. Water leakage	1. Number of people with access to clean water 2. Proportion of electricity usage
	2. Employment and Poverty (income level)	1. Jobs created 2. Agricultural profit		
	3. Developing Solutions	1. Technology application 2. Policy adoption	Technology knowledge shared and transferred	Number of people with access to knowledge sharing by key persons

Country	Objective to measure	What to measure	Applicable Indicators	How to measure
Viet Nam	1. Strengthened WEF Security	Improvement of WEF consumption and production	1. Quantity of Water Consumption/Proportion of Household accessible to clean water, 2. Proportion of Renewable Clean Water, 3. Proportions of renewable energy of total electricity, 4. Agricultural productivity 5. Women's labor input on WEF production (realistically difficult)	Provincial/ District/ Commune gov. level
	2. Employment and Poverty (income level)	1. Jobs created 2. Agricultural profit	Jobs created 1. Employment on Facility installed and/or related, 2. Women's attend Capacity training? Agricultural profit 1. Income from agriculture per annual work unit, 2. Number of agriculture products for sale	Provincial/ District/ Commune gov. level
	3. Developing Solutions	1. Technology application 2. Policy adoption	Technology application 1. Facility installed and operated 2. Technology knowledge shared and transferred Policy adoption (This is quite difficult, since the pilot project does not have any policy component.)	Project team

Annex E: Stakeholder Engagement Analysis

Country	Stakeholder	Currant Collaboration States	Action to Enhance Collaboration
Cambodia	local community • Member • Committee • women • minority people • indigencies people	Medium	• Participate in meeting in planning • Participate in training in agricultural techniques/clean water • Participate in project implementation • Engagement with local Authorities
	Local Authorities (village, CC, DC)	High	• Conduction meeting on need assessment in community (situation analysis) - issues/challenges - solutions • regulate update with community on project progress
	National Level	High	• Coordinate Facilitate with line ageing, NGOs relevant stakeholders • Project monitory • Networking with relevant stakeholders
Lao PDR	Nakeaw farmers group	Low	Strengthening farmer group (skill, Management, tools, etc.)
	Provincial leader	Medium	Field visit, public hearing, linking the solution
	Central Leader (government)	High	Facilitate all related requirements from the project
Thailand	Local Community	Medium	Receive the information related to project via the community meeting
	Bungkhla subdistrict Administrative Organization	High	Building the common codenaturing on project toward the related agencies (internal l& external stakeholder)
	TNMCS	High	Maintain collaboration ensure the project meet the local regiment

Country	Stakeholder	Currant Collaboration States	Action to Enhance Collaboration
Viet Nam	Provincial PC	Low	Report regularly to update info. & seek instruction
	Provincial Department	High	• Maintain regular communications • Training for capacity building
	Commune PC	Medium	• Update project info. • Seek advice to engage with communities & collect info.

Annex F: Developing Communication Strategies

Country	Stakeholder	Communication Strategies
Cambodia	Local Community	• Improve livelihood in community • Development in community - Infrastructures (irrigation, system, solar, clean water facilities) • Improve knowledge on Agriculture technique water supply and sanitation • Transparency
	National agencies +DP	Support final
Lao PDR	Local farmer	Our project will support irrigation system improvement electrical transformer for water supply and water monitoring system
	Provincial leader	The main objective of our project is sustaining and developing water system at local community at rural are for increasing production area
Thailand	Bungkhla subdistrict Administrative Organization	• Assist the local to cope with Tap water issue • Improve the livelihood of people • Introducing new Technology & innovation • Developing tap water system & water quality in Bung Khla

Country	Stakeholder	Communication Strategies
Thailand	TNMCS	• Introducing the National Pilot Project • Introducing new technology and innovation to coping with issues for the selected pilot area • Solving the issues with WEF Nexus
Viet Nam	Provincial PC	Report regularly to update info. & seek instruction
	Provincial Department	• Maintain regular communications • Training for capacity building

Annex G: Project Risk Matrix and Mitigation Strategy Development

Cambodia

Risk Matrix	Potential Consequence		
	Low 1-3	**Med 4-6**	**High 7-9**
Rae 1-3	C2 (3x2=6)		
Possible 4-6	• B4(3x5=15) • C1(3x6=18)	B2 (5x4=20)	D1 (7x6=42)
Likely 7-9		B3 (6x7=42)	• B1 (8x8=64) • A2 (7x7=49) • A1 (8x7=56)

Mitigation strategy D&R Priorities			
Logistical	**Regulatory**	**Technical**	**Funding**
Delay in receiving grants (score:56) • Project team + Donor work closely	Project official approval delay (score:42) • National agencies/donor work closely	Procurement process is complicated/ slow: (score :64) • Project SOP (procurement management) • Recruitment procurement expert	Project financial management is complicated (Score:49) • Project FM (SOP) • Recruitment financial expect

Lao PDR

Risk Matrix	Potential Consequence		
	Low 1-3	Med 4-6	High 7-9
Rae 1-3		Funding (5x2=10)	
Possible 4-6		• Technical (5x4=20) • Regulatory (5x5=25)	
Likely 7-9			Logistical (8x8=64)

Mitigation strategy D&R Priorities			
Logistical	**Regulatory**	**Technical**	**Funding**
(score:64) • Focusing on project implementation in dry season • Online project management system	(score:25) Early assessment and preparation of new river basin planning	(Score:20) Train the local people and maintain project equipment	(Score:10) Prepare contingency budget

Thailand

Risk Matrix	Potential Consequence		
	Low 1-3	**Med 4-6**	**High 7-9**
Rae 1-3	Select the unprepared in spallation area (2x2=4)		Legislation and Authority of implementing agencies (2x8=18)
Possible 4-6		Insufficient training of local technicians responsible for maintenance (5x5=25)	Insufficient financial resource for the implementation (O&M) (5x8=40)
Likely 7-9			

Mitigation strategy D&R Priorities			
Logistical	**Regulatory**	**Technical**	**Funding**
Select the unproper installation area (Score:4) MSD: • consult with the local who is familiar with the area to find the appropriate area to installation • conduct the installation plan	Legislation and Authority of implementing agencies (Score:16) MSD: consult with the authority person and communication leader on legislation and authority of implementing agencies role and responsibilities of project implementation	Insufficient training of local technicians responsible for maintenance (score :25) MSD: • Update the project regular to make a clear picture of the project • Conduct the capacity building program for the local organization • Consult with the local leader for the designated person who is charge of technical maintenance	Insufficient financial for the implementation (O&M) (Score:40) MSD: • planning the budget used for the project implementation covering operation and maintenance

Viet Nam

Risk Matrix	Potential Consequence		
	Low 1-3	**Med 4-6**	**High 7-9**
Rae 1-3	• Tech not effective (1x3=3) • Limit GW extraction (3x3=9) • Import vs plan (3x2=6)	replacement tech/design	Insufficient GW capacity (3x9=27)
Possible 4-6	• O & M post project (4x3=12) • Regulatory changes (5x2=10)	• Insufficient operation cap. (4x4=16) • Land availability & solar capacity (5x6=30)	• Training • Identify alternatives
Likely 7-9	• Counterpart funding delay/insufficient (7x3=21) • Delay with approval process (9x3=27)	• Spare parts not available (9x5=45) • Difficult for const. During rainy season/tide (7x4=28)	• design identify sources • Appropriate construction me same/ timing

Mitigation strategy D&R Priorities			
Logistical	**Regulatory**	**Technical**	**Funding**
• Import process vs plan • Difficult for construction during rainy season / high tide	• Delay with approved processes • Limitations with GW extraction • New regulation changes	• Insufficient GW capacity • Technology not effective • Insufficient local operation capacity • Spare parts not easily available • Land availability & solar capacity	• Counterpart funding for network connection delayed/insufficient • O&M budge post project

Annex H: National Pilot Information Note Template

Cambodia

1.Project Title	Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng
2. Location	Sdao Commune, Sesan district, Stung Treng province
3. Duration/Timeframe	January 2024 – June 2025
4. Estimated Total Budget	500,000US$
5. Objectives	Improve clean water access by using renewable energy. Improve agricultural productivity for food security.
6. Expected Outcome and outputs	Outcome 1: More people are accessible to clean water. Output 1: # of household in the community access to clean waterOutput 2: # of water storage/pipe using solar are built/installed.Outcome 2: Increased agricultural products.Output 1: Increased irrigated areas.output 2: Increased knowledge's farmers on agriculture techniques, crop diversification and integrated aquaculture.
7. Key Activities	Conducting baseline survey & feasibility studyProviding access to safe drinking water by purifying groundwater Rehabilitating irrigation system/water infrastructure, pumping station (including water tanks), and small-scale solar farm.Diversifying crop production through improved irrigation systems and technologyPromoting aquaculture (integrated aquaculture/fishpond) Providing capacity building to project members, CFi, and water use communities
8. WEF nexus elements	Select relevant coverage: Water Energy Food
9. Technical Solutions	ROK solutions
10. Capacity Building elements (Regional and national)	Regional capacity building by STEPI, MI, UNOSSC, MRCS National capacity building (project staff and working group)Subnational capacity building (local authorities, local communities)
11. Engaged Stakeholders	National, provincial, local authorities and communities, NGOs, academia, MRCS, and relevant project teams
12. Situational Analysis (Background)	To be conducted
13. Baseline (target beneficiaries) (feasibility requirements)	To be conducted
14. National Project Implementation Structure	Project Team Structure (National/Local project implementation structure, focal points), National, provincial, local authorities and communities

15. Workplan (by activity and budget)	Baseline survey & feasibility study Water storage and other facilities buildingEquipment and materials Solar pump installationRehabilitation of ruination system Capacity building (project team, project working group, farmer training on agricultural techniques and water management)Consultative and dissemination workshops Administration and consultant services
16.Tentative Timeline	Nov 2023-June 2025-Baseline survey-Official Approval -Pilot roll out
17. Monitoring and reporting	Six-monthly progress report and completion report

Lao PDR

1.Project Title	A Centralized Data Center and Situation Room at the National Level for Water Management (Case Study Xebangfai River Basin)
2. Location	Lao National Mekong Committee Secretariat01000, Nong Beuak Road, Sikhottabong District, Vientiane Capital, Lao PDRNakio Village, Mahaxay district, Khammuan district
3. Duration/Timeframe	January 2024 – June 2025
4. Estimated Total Budget	~ Max 500,000 USDCost sharing (if any)
5. Objectives	This project aims to improve and integrate the platform of flood and drought forecasting, early warning management mitigation associated with reservoir monitoring and control.The specific objective is to:Improve the operational system;Strengthen the institutional capacity;Formulate the working mechanism among key stakeholders.
6. Expected Outcome and outputs	The expect outcome from this project:The operational system including the system and operational room is renovated and upgraded.The institutional capacity is strengthened with the ability to operate and maintain the system.The working mechanism is identified clearly in which each stakeholder has the clear and right mandate to support the implementation of national water control.To fulfill the outputs are also identified as follows:Output 1 The project shall be implemented successfully within the timeframe;Output 2 The water control system is reinvigorated successfully to integrate flood and drought forecasting and management with reservoir operation;Output 3 the institutional capacity is strengthened ensuring the system can be operated and maintained effectively.
7. Key Activities	From the above-mentioned output, these are key activities:Activity 1.1 Administrate and Manage the project on time;Activity 1.2 Monitor and Evaluate the project;Activity 1.3 Promote and Enhance the cooperation and coordination of each stakeholder;Activity 2.1 Review the existing operational system;Activity 2.2 Redesign the operational system;Activity 2.3 Reinvigorate the operational system;Activity 3.1 Conduct capacity need assessment;Activity 3.2 Conduct the short-term capacity (workshop or training);Activity 3.3 Upgrade the knowledge of the staff in long-term model.
8. WEF nexus elements	Water Energy Food
9. Technical Solutions	ROK solutions [STEPI filled]
10. Capacity Building elements (Regional and National)	[MI]

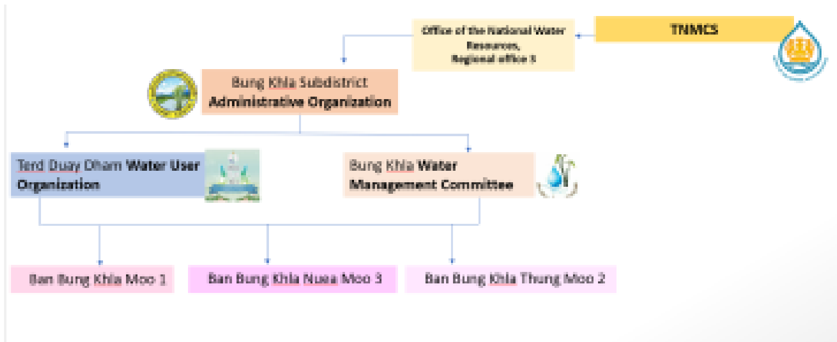
11. Engaged Stakeholders	Ministry of Natural Resources and Environment: Department of Meteorology and Hydrology, Department of Water Resources, Lao National Mekong Committee Secretariat;Ministry of Energy and Mines: Department of Energy Policy and Planning;Ministry of Agriculture and Forestry: Department of Irrigation;Ministry of Labor and Social Welfare: Department of Social Welfare, National Disaster Management Committee;Hydropower Dam Developers;Faculty of Water Resources, NoUL;Local Authorities: Natural Resources and Environment Provicial Department, Natural Resources and Environment District Office, Khammouane Province-Transition Plan Implementation Management Unit.
12. Situational Analysis (Background)	Hydropower development has been a key pillar of Lao PDR's economic development over the last 20 years and continues to form a central part of its plans for economic growth. The development of hydropower plants and the construction of a large number of water reservoirs on many of its rivers has changed flow regimes and impacted the management of the country's water resources.Lao PDR experiences water management issues such as flooding and drought, in line with its seasonal, tropical climate. These flow management issues have been exacerbated by climate change and the development of hydropower across the country, due to the operational requirements of electricity generation – requiring storage and discharge of river flow that can disrupt a natural flow regime. The economic benefits of the development of hydropower have come at a cost to the local environment, communities within dam development sites, and downstream water users.There is a recognized need to better manage or "coordinate" flows to balance the use of water by larger industries, such as hydropower generation, with the needs for river health, biodiversity, community safety, agriculture, tourism, cultural flows, ecosystem services, fisheries, navigation, and catchment management. The better flow management requires a centralized data center and situation room to monitor, forecast flow for short, medium, long-range and disseminate to the local community and relevant stakeholder on time, preventing the damage from the flood and drought that may occurs.

13. Baseline (target beneficiaries)(Feasibility requirements)	The overall concept of a centralized data center and situation room shall consist of 3 main components: Field Data Monitoring; Data Analysis and Evaluation and Data and Information Dissemination.Component 1: Field Data Monitoring: refers to the hydro-met network system which is telemetry and manual. In addition, this also includes the early warning system such as alarming post. Apart from that, this component shall have discharge, cross-section, and sediment measurement and longitudinal Profile survey;Component 2: Data Analysis and Assessment: refers to reservoir optimization system by using decision support system. Within this system, there is dashboard, climate and hydrology model, river monitoring and reservoir operation system integrated with component 1. This system can be developed as supervisory control and data acquisition (SCADA);Component 3: Data and Information Dissemination: refer to mechanism and channel to disseminate the information which can be website, mobile application, media and socio-media. In addition, this also refer to the information which is published to other sectors including warning speaker and warning post.
14. National Project Implementation Structure	Lao National Committee Secretariat is the project management unit.National Working Group consists of key line agencies: Department of Meteorology and Hydrology, MoNRE;Department of Water Resources, MoNRE; Department of Energy Policy and Planning, MEM;Department of Irrigation, MAF;Department of Social Welfare, MLSW;National Disaster Management Committee; Hydropower Dam Developers; Faculty of Water Resources, NoUL; Local Authorities: Natural Resources and Environment Provicial Department, Natural Resources and Environment District Office, Khammouane Province-Transition Plan Implementation Management Unit.
15. Workplan (by activity and budget)	OutputsIndicatorsActivitiesBudget (USD)Output 1: The project shall be implemented successfully within the timeframeDisbursement rate and timelineA.1.2 Administrate and Manage the project on time50,000A1.3 Monitor and Evaluate the project20,000A.1.3 Promote and Enhance the cooperation and coordination of each stakeholder30,000Output 2: The water control system is reinvigorated successfully to integrate flood and drought forecasting and management with reservoir operationSystem is well reinvigoratedA2.1. Review the existing operational system50,000A.2.2.

	Redesign the operational system50,000A.2.3. Reinvigorate the operational system200,000Output 3: the institutional capacity is strengthened ensuring the system can be operated and maintained effectivelyTechnical officials are able to operate and maintained the system efficientlyA3.1. Conduct need assessment10,000A.3.2. Conduct the short-term capacity (workshop or training)40,000A.3.3. Upgrade the knowledge of the staff in long-term model50,000Total500,000
16.Tentative Timeline	18 Months (January 2024 – June 2025)Month 1-3:Project planning: Define the project scope, goals, and objectives. Identify and assess risks. Create a detailed project plan, including a timeline, budget, and resource allocation.Team formation: Assemble a team of qualified and experienced individuals to complete the project.Kickoff meeting: Hold a kickoff meeting to introduce the project team, review the project plan, and answer any questions.Month 4-6:Design phase: Develop and refine the project design. This may involve creating prototypes, conducting user testing, and making necessary revisions.Development phase: Begin developing the project, according to the project plan. Month 7-9:Testing phase: Thoroughly test the project to ensure that it meets all requirements and is free of defects. This may involve unit testing, integration testing, and system testing.Deployment planning: Develop a plan for deploying the project to its production environment. This may involve developing training materials, creating documentation, and migrating data.Month 10-12:Deployment: Deploy the project to its production environment. This may involve installing software, configuring hardware, and training users.Post-deployment support: Provide post-deployment support to users, as needed. Month 13-18:Project closure: Complete all project tasks and deliverables. Close out the project budget and resources. Hold a project closure meeting to review the project's successes and challenges and learn from the experience.
17. Monitoring and reporting	[UNOSSC]

Thailand

1.Project Title	Increasing the Efficiency of Tap Water System in Moo 1,2 and 3 Bung Khla Sub-district, Bueng Kan Province
2. Location	LOCATION Moo 1,2 and 3 Bung Khla Subdistrict Bueng Kan Provinces • Ban Bung Khla Moo 1 48Q 394820.19E , 2021973.59N • Ban Bung Khla Thung Moo2 48Q394357.30E , 2022092.84N • Ban Bung Khla Nuea Moo 348Q3933.96.13E , 2023705.99N
3. Duration/Timeframe	(Will be determined after the field visit)
4. Estimated Total Budget	Max 500,000 USD (implementation, operation and maintenance)
5. Objectives	• People can access clean water for household use. • The production capacity of tap water can serve the demand of people at the present and in the future when the number of households and population are increased. • Decrease the cost of tap water production • Pilot project for other villages along Mekong River
6. Expected Outcome and outputs	- Technology that matched with the needs of locals
7. Key Activities	- Improve Filtration system - Introduce Leaking detection technology - Introduce solar pumping system
8. WEF nexus elements	Select relevant coverage: Water Energy
9. Technical Solutions	ROK solutions
10. Capacity Building elements (Regional and national)	- Introducing the technology and innovation from Korean side for other villages along Mekong River - Conduct the capacity building for the technician to maintain the technology - Create a common understanding in the community and related stakeholders
11. Engaged Stakeholders	- Bung Khla Subdistrict Administrative Organization - Terd Duay Dham Water User Organization - Bung Khla Water Management Committee - Office of the National Water Resources - Office of the National Water Resources, Regional office 3 - UNOSSC - STEPI - Others

12. Situational Analysis (Background)	- Fluctuation of Mekong River in wet and dry season - The long distance of pumping water causes water pipes to leak in some places and leading to water contaminated and poor standard (cloudy tap water) - Also increases the cost of pumping including electricity costs, longer water pipes, and maintenance cost.
13. Baseline (target beneficiaries) (feasibility requirements)	Beneficial area/ Number of benefited households and population: Ban Bung Khla Moo 1 268 households 614 people Ban Bung Khla Thung Moo 2 476 households 1,202 people Ban Bung Khla Nuea Moo 3 190 households 549 people 70% of the population work as farmers Further study: - Income - Socio economic - Water supply and water use - Electricity use - Water management
14. National Project Implementation Structure	Project Team Structure (National/Local project implementation structure, focal points) 
15. Workplan (by activity and budget)	Site visit on 20 October 2023 - Consult with local community/leader - Baseline survey - Official approval - Launch the project
16.Tentative Timeline	(Will be determined after the field visit)
17. Monitoring and reporting	(Will be determined after the field visit)

Viet Nam

1.Project Title	Improvement of Livelihoods through the Application of WEF Nexus Approach in the Mekong Delta of Viet Nam
2. Location	Con Linh (Linh Island), Thanh Phu Dong Commune, Giong Trom District, Ben Tre Province, Viet Nam
3. Duration/Timeframe	January 2024 – June 2025
4. Estimated Total Budget	P-LINK: approx. 500,000 USD Cost sharing (if any) TBC
5. Objectives	Improvement of access to clean water through application of WEF Nexus Approach;Improved livelihoods through better access to clean water.
6. Expected Outcome and outputs	Outcome 1: Increased households' access to clean water via application of WEF solutions. Output 1.1: Construction of WEF facilities;Output 1.2: Households access to WEF solutions.Outcome 2: Capacity built for WEF application.Output 2.1: Capacity building training organized;Output 2.2: Dissemination on WEF Nexus application and sustainable water use.
7. Key Activities	- Conduct baseline survey & FS;- Prepare and approval of design for WEF facilities;- Installation and construction of WEF facilities;- M&E;- Capacity Building and dissemination.
8. WEF nexus elements	Select relevant coverage: Water Energy Food
9. Technical Solutions	ROK solutions
10. Capacity Building elements (Regional and national)	- Regional capacity building;- National capacity building (local level).
11. Engaged Stakeholders	VNMCBen Tre Provincial PCRelevant Ben Tre Provincial Departments (DONRE, DARD, DPI...)Giong Trom District PCThanh Phu Dong Commune PCLocal communitiesOthers where appropriate
12. Situational Analysis (Background)	Location, area of the pilot project site;Population, demographic;Natural conditions and socio-economic situation;Water supply situation and demand;Relevant national and local regulations and plans.
13. Baseline (target beneficiaries)(feasibility requirements)	No. of households with access to water supply;Water & energy demand (for private use and production);Water & energy costs;Gender distribution (where applicable).

14. National Project Implementation Structure	Project Team Structure Provincial-level PMU (TBC by provincial PC);VNMC has coordinating, monitoring and evaluating role.
15. Workplan (by activity and budget)	TBC by project team
16.Tentative Timeline	Tentatively, at minimum:Agreement process: 3 months;Project documents approval and internal process (provincial level): 3 months;Project design: 3 months;Project construction: 3 months.
17. Monitoring and reporting	TBC by project team, however M&E post project could also be conducted to fully evaluate the economic effectiveness of the pilot.

Annex I: Directory

No.	Photo	Name & Position	Organization & Address	Contact Information
CAMBODIA				
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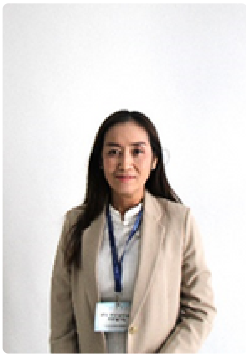
6.		**Mr. Laty Souliyadeth** Management - planning	Transition plan Implementation management Unit ViengChan Road,Chomkeo village, Thakhek District, Khammuane, Lao PDR	Mobile: +856 2055269828 E-mail:Latee_ty@hotmail.com
7.		**Ms. Hongkham Vongsay** Senior Technical Officer	Ministry of Natural Resources and Environment (MoNRE) 01010, Dongnaxok-Nongbeuk Road, Sikhottabong District Vientiane, Lao PDR	Mobile: +856 2058646511 E-mail: v.hongkham@gmail.com
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Viet Nam				
14.		**Mr. Nguyen Xuan Tung** Official	Vietnam National Mekong Committee (VNMC) 23 Hang Tre Ha Noi, Vietnam	Mobile: E-mail: xuantungnguyen.mk@gmail.com
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Resource Persons

No.	Photo	Name & Position	Organization & Address	Contact Information
1.		**Mr. Youngwoo Kim** Environmental Advisor	United Nations Development Programme, Bangkok Regional Hub, Thailand United Nations Building., 12th Floor, Rajdamnern Nok Avenue, Bangkhunprom, Phranakorn Bangkok, Thailand	Mobile: +66 822198813 E-mail: youngwoo.kim@undp.org
2.		**Dr. Atsamon Limsakul** Director of Climate Change Adaptation Research Group	Climate Change and Environmental Research Center Bangkok, Thailand	E-mail: atsamonl@gmail.com

Implementing Partners:

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1.		**Ms. Yejin Kim** Project Manager of RoK-UNOSSC Facility Phase 3/P-LINK	United Nations Office for South-South Cooperation Bangkok, Thailand	E-mail: yejin.kim@unossc.org
2.		**Dr. Hwanil Park** Chief Director and Senior Research Fellow, Division of Global Innovation Strategy Research	Science and Technology Policy Institute (STEPI) 5~7th Fl, Building B, Sejong National Research Complex, 370 Sicheong-daero, Sejong, 30147, Republic of Korea	Tel: 82-44-287-2461 Fax: 82-44-287-2196 Mobile: E-mail: hipark@stepi.re.kr
3.		**Dr. Dongun Park** Associate Research Fellow, Office of Sustainable Innovation Policy Research	Science and Technology Policy Institute (STEPI) 5~7th Fl, Building B, Sejong National Research Complex, 370 Sicheong-daero, Sejong, 30147, Republic of Korea	Tel: 044-287-2275E-mail: dupark@stepi.re.kr
4.		**Mr. Thanawat Wetchapan** Strategy and Partnership Project Assistant	Mekong River Commission Secretariat Quai Fa Ngum, Vientiane, Lao PDR	E-mail: thanawat@mrcmekong.org

MI Organizing Team:

No.	Photo	Name & Position	Organization & Address	Contact Information
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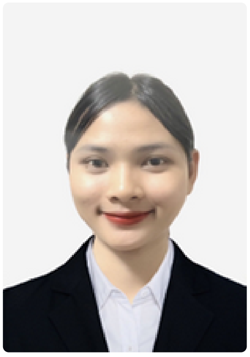
3.		**Ms. Yupaporn Siribut** Program Officer, Sustainable Energy and Environment Department	Sustainable Energy and Environment Department Mekong Institute Khon Kaen, Thailand	Tel: +66 (0) 43 202 411 ext. 4104 Fax: +66 (0) 43 203 656 Email: chakdao@mekonginstitute.org
4.		**Ms. Kademanee Suthum** Project Operations Support Assistant	Sustainable Energy and Environment Department Mekong Institute Khon Kaen, Thailand	Tel: +66 4320 2411 ext. 4105 Fax: +66 4320 3656 Mobile: +66 (0) 94 7361136 Email:kademanee@mekonginstitute.org

Annex J: Program Schedule

Day 1 (Monday, October 16, 2023)		
Time	**Cintents/Sessions**	**Resource Person/Facilitator**
08.30 – 09.00	Registration	**MI**
09.00 – 09.30	Welcome and Opening Remarks	**MI and UNOSSC**
09.30 – 09.35	Group Photo	**MI**
09.35 – 10.15	**Setting the Context** • Video Presentation • MI Facilities Introduction • Program Overview (P-Link Project and Training workshop) • Getting to Know Each Other	**MI and UNOSSC**
10.15 – 10.35	Coffee Break	
10.35 – 11.00	• Exploring Expectations and Setting Norms • Event Board of Directors (BOD) • Pre-Assessment	**MI**
11.00 – 11.30	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus** • Concepts and Definitions • Overview of the Interconnections and Trade-offs	**Dr. Atsamon Limsakul** Director of Climate Change Adaptation Research Group Climate Change and Environmental Research Center
11.30 – 12.00	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus Case Studies** • Examples of Successful Nexus Projects and Initiatives • Challenges Faced in Implementing Nexus Approaches • Lessons Learned and Recommendations	**Dr. Atsamon Limsakul**
12.00 – 13.30	Lunch Break	
13.30 – 14.00	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus** • Role of Science, Technology, and Innovation (STI) in Integrated Development	**STEPI**
14.00 – 14.30	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus** • Case Studies (Cont.)	**STEPI**
14.30 – 15.00	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus** Case Studies (Cont.) • Ongoing Related Initiatives	**Mr. Youngwoo Kim** Environment Advisor The Nature, Climate and Environment (NCE) Team UNDP
15.00 – 15.20	Coffee Break	

15.20 – 16.45	**Module 1: Introduction to Water-Energy-Food (WEF) Nexus** • Interactive Exercise	**Dr. Atsamon Limsakul and MI**
16.45 – 17.00	BOD Meeting	**MI and Participants**
18.30 – 20.00	Welcome Dinner	
Day 2 (Tuesday, October 17, 2023)		
08.45 – 09.00	Recap	**MI**
09.00 – 09.45	**Module 2.1: Introduction to National Pilot Design and Indicators** • National Status and Policies related to WEF Nexus	**MRCS and NMCs**
09.45 – 10.30	**Module 2.1: Introduction to National Pilot Design and Indicators** • Introduction to Pilot Design • Purpose of Pilots • Types of Pilots • Key Components of a Pilot	**STEPI**
10.30 – 10.50	Coffee Break	
10.50 – 12.00	**Module 2.1: Introduction to National Pilot Design and Indicators** Identifying Indicators • Process of Selecting and Prioritizing Indicators • Criteria for Selecting Indicators Social and Environmental Standards • Including gender equality, vulnerable groups, safeguard and grievance mechanisms, etc. Developing a Theory of Change • How will the Indicators Measure Progress toward Outcomes	**STEPI**
12.00 – 13.30	Lunch Break	
13.30 – 15.00	**Module 2.2: Application of National Pilot Indicators** Group Activity • Discuss the List of Indicators and Select the Ones that are Most Suitable for Assessing Progress in the Given Scenario (MRCS)	**STEPI (with support from UNOSSC, MRCS, MI)**
15.00 – 15.20	Coffee Break	

15.20 – 16.45	**Module 2.2: Application of National Pilot Indicators** Scenario-based simulation: comparison between the present and future (with pilot interventions) Data Collection Methods • Different Methods of Data Collection • Develop Data Collection Instruments Data Analysis • Clean and Prepare Data • Analyze Quantitative and Qualitative Data • Present Data in a Meaningful Way Reporting • Write Clear and Concise Reports that Communicate the Results of the Pilot Evaluation • Develop Evaluation Plans • Measure the Success of the Pilot	**STEPI (with support from UNOSSC, MRCS, MI)**
16.45 – 17.00	BOD Meeting	MI and Participants
Day 3 (Wednesday, October 18, 2023)		
08.45 – 09.00	**Recap**	**MI**
09.00 – 09.45	**Module 3: National Pilot Project Implementation and Management** P-LINK Project Management and Key Skills • Project Design • Standards • Risk Management • Financial Management • Critical Path Planning • Coordination • Communication • Stakeholders Engagement	**UNOSSC**

09.45 – 10.30	**Module 3: National Pilot Project Implementation and Management** Skill Integration Exercise: Applying Key Skills to the National Pilot Project Implementation • Component I: Stakeholder Engagement • Component II: Coordination and Communication Strategies	**MI (with support from UNOSSC, STEPI, MRCS)**
10.30 – 10.50	Coffee Break	
10.50 – 12.00	**Module 3: National Pilot Project Implementation and Management** Skill Integration Exercise (Cont.) • Component III: Financial Management • Component IV: Risk Identification	**MI (with support from UNOSSC, STEPI, MRCS)**
12.00 – 13.30	Lunch Break	
13.30 – 15.00	**Module 3: National Pilot Project Implementation and Management** Skill Integration Exercise (Cont.) • Group Presentations and Discussion	**MI (with support from UNOSSC, STEPI, MRCS)**
15.00 – 15.20	Coffee Break	
15.20 – 16.45	**Module 3: National Pilot Project Implementation and Management** Action Plan: Steps/Actions to Implement and Manage the National Pilot Project • Introduction to the Project Information Note • Action Plan Development Orientation • Action Plan Preparation	**MI (with support from UNOSSC, STEPI, MRCS)**
16.45 – 17.00	BOD Meeting	**MI and Participants**
18.30-20.00	Farewell Dinner	
Day 4 (Thursday, October 19, 2023)		
08.45 – 09.00	Recap	**MI**
09.00 – 10.10	**Module 3: National Pilot Project Implementation and Management** • Action Plan Presentation (15 minutes per country) • Introduction to Next Steps -Technology -Capacity building	**MI and STEPI**
10.10 – 10.30	Coffee Break	
10.30 – 11.00	• Post-Assessment • Course Evaluation	**MI**

11.00 – 11.45	**Closing Ceremony** • Course Report • Speech from Participants • Awarding of Certificates • Closing Remarks	**MI**
11.45 – 12.00	BOD Meeting	**MI and Participants**
12.00 – 13.30	Lunch Break	

Annex 6

Draft as of 25 Sep 2023

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

NATIONAL PILOT INFORMATION NOTE TEMPLATE

1.Project Title	
2. Location	
3. Duration/Timeframe	
4. Estimated Total Budget	P-LINK Cost sharing (if any)
5. Objectives	
6. Expected Outcome and outputs	
7. Key Activities	
8. WEF nexus elements	*Select relevant coverage:* Water Energy Food
9. Technical Solutions	*ROK solutions*
10. Capacity Building elements (Regional and national)	
11. Engaged Stakeholders	
12. Situational Analysis (Background)	
13. Baseline (target beneficiaries) (feasibility requirements)	
14. National Project Implementation Structure	*Project Team Structure (National/Local project implementation structure, focal points)*
15. Workplan (by activity and budget)	
16.Tentative Timeline	
17. Monitoring and reporting	

Annex 7

6 November 2023

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

CAMBODIA NATIONAL PILOT- BASIC SURVEY

"Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng, Cambodia"

Background

The "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. Also known as the RoK-UNOSSC Facility (Phase 3)/P-LINK, the project takes integrative and multi-sectoral approaches in the application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation (SS & TrC) modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea (ROK), and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) and will enlist the support of other UN Agencies.

In addition to knowledge generation, advisory services, and multi-sectoral platform, the project will carry out national technology pilots in the four participating countries. Following a series of regional and national consultations, a national pilot entitled, "Improving Access to Clean Water and Increasing Food Security in Sdao Commune, Stung Treng[1]" will be implemented in Cambodia. Covering all three elements of the Nexus, the pilot aims enhance access to clean water by using renewable energy and foster agricultural productivity for food security in the community. The pilot will provide a solar power generated water treatment system and agricultural capacity support by introducing appropriate ROK solutions tailored to the local needs *(Annex 1: Technology Proposal)*. The 18 months pilot is expected to roll out in the first quarter of 2024.

In this background, the Project Team would like to better understand present situation in Sdao Commune, Sesan district including beneficiaries and village facilities that will be benefitted by the pilot. The Project Team will liaise with the Cambodia National Mekong Committee (CNMC) to hire one/two local expert(s) to conduct the basic survey.

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[1]Stung Treng is a province located in Northeast of Cambodia with an area of 11,092km^2 total population of 165,713 as of 2019 (2019 National Census Report). The province is divided into 5 districts, 1 municipality, 34 commune and 128 villages.

Proposed National Pilot Indicators and measurement methods[2]

Objective to measure	What to measure (Component, Element)	Indicators	How to measure
1. Strengthened WEF Security	Improvement of WEF consumption and production	① Quantity of Water Consumption/Proportion of Household accessible to clean water, ② Proportion of Renewable Clean Water, ③ Proportions of renewable energy of total electricity, ④ agricultural productivity *(to be specified)*	• Baseline and endline comparison by Project Team and hired consultant
	Damage from flood disaster per year	① Number of death and injury, ② Loss of livestock, ③ Property loss	..
2. Employment and Poverty (income level)	Jobs created	① Employment on Facility installed and/or related, ② Women's employment (# and %) ③ Poverty reduction rate	..
	Agricultural profit	① Income from agriculture per annual work unit (individual/household/community, $/year), ② Number of agriculture products for sale (Type of agricultural products for sale, kg/ton)	..
3. Developing Solutions	Technology application	① Facility installed and operated ② Technology knowledge shared and transferred	..
	Policy adoption	① WEF Nexus Policy established by central or local government[3]	..

*blue notes: inputs from Cambodian delegation

Purpose of the Survey

- To take stock of the current situation of water, energy and food management in identified pilot site, Sdao Commune to set specific baseline data related to social, economic, environment, and policy aspects prior to the application of proposed technology solution. It will require both quantitative and qualitative data collection and analysis.
- To identify project scope, specific target beneficiaries and capacity building needs in the pilot site as well as finetune the pilot design.
- To facilitate and propose measurement of pilot indicators to monitor impact of the project related to social, economic, environment and policy.
- To provide basic information to community members and engaged national and local stakeholders about the pilot in order to enable them to have a role in establishing working groups to implement, monitor and manage the project before and after the installation of the new technology and capacity building activities.
- To coordinate efforts between government officials at national and local levels in the installation of the technology in the pilot site.

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[2] Indicators prepared by STEPI incorporating Cambodia delegations' inputs and feedback during the 1st Regional TOT.

[3] Govt. stakeholders understand the WEF nexus policy and considers it a priority and intends to invest continuously. Coordination between the central government and Local-level decision-making will determine how trade-offs and synergies in the WEF nexus are implemented. The capacities of local government organisations and decision-makers need to be strengthened to enhance their capacity to adopt nexus approaches and coordinate vertically.

Scope of Work

- Primary and secondary data collection (both quantitative and qualitative)
- Survey the current status of facilities, equipment and system

Duration

- Around 1-2 workdays (depending on travel time to pilot site)

Budget

- Maximum USD 2,000

Local Expert Contract Modality

- Via STEPI

Target Respondents

- Local government (Stung Treng province and Sesan district)
- Community leaders and members of Sdao Commune)

Assessed Topics

- National/Local policy frameworks related to water, energy and food management
- Local demographic information about general info about Stung Treng and Sdao commue (population, households, income level, age groups, gender, climate, wet/dry seasons, land size)
- Community governance/groups (agriculture/fishery cooperatives)
- Main source of economy (e.g. agriculture, major produce)
- Water supply/management information (e.g. monthly consumption amount, cost per unit)
- Electricity accessibility/alternative energy source, main usage (e.g. household, agriculture)
- Technical profile and cost of existing facilities used for food, water and energy supply
- Food security
- Household status (e.g. female-headed vs. male-headed HHs, HHs with disability and/or more dependents)
- Households operating mono-cropping and those involved in integrated farming systems and /or multi-cropping practices,
- Level of household dependence on livestock raising for either household consumption and /or selling
- Level of household dependence on water supply for both household consumption and agricultural production
- Level of household dependence on electricity/renewable energy for household consumption and agricultural production

BASIC SURVEY REFERENCE MATERIALS

I. GUIDING QUESTIONS FOR KEY INFORMANT INTERVIEW (e.g. major, community leaders, etc.)

Date:	Time:
Interviewer's name:	Position:
Village:	Commune:

- Please provide basic demographic information of Sdao commune 1 & 2 in terms of
  - Climate characteristics (dry/wet season, floods/droughts, etc.)
  - # Population (gender, age groups)
  - # Household (household type such as female/male headed, size)
  - Community governance structure
  - Main source of income
  - # of mobile users
- What are current local economic drives and livelihood situations in the locality over the last five years?
- What is the average quantity of water consumption of the Sdao commune per quarter/year?
- What percentage/# of the households have access to clean water?
- Is there any community facility for water supply? How is water distributed to each household? What is the price of water per unit (cm^3)? How is the water usage bill collected?
- How many water supply facilities are there in Sdao commune? How much did the commune invest to install these facilities? For example, what is the size of the existing water tank facility? What are the specific components/equipment of this facility? What was the installation price? Is there any maintenance fee per month?
- In your opinion, what is the extent of local communities' capacity (technical, financial, governance) in terms of livelihood improvement and climate change adaption particularly related to water, energy (renewable) and food management and security?
- What climate change adaption would you like to see happen in your locality? Do you have any suggestion or recommendation for improving the community livelihood and also responding to climate change?
- Does your district/commune follow any national/local policy on integrated management of water, energy and food?

II. GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSION

- Village's name where FGD conducted.
- Date and time for FGD conduct.
- Number of participants and discussants involved. Enclose the attendance list to the report.
- Occupations of villagers (established members and common villagers) and percentage of villagers involved in each occupation.
- Current situation of water access and consumption, including main water sources for household use and agricultural production in the village. What is the monthly water usage expense on average? How does your household get water supply, is it from the community water tank or via surface water from the river?
- Current situation of energy access and consumption, including main source of electricity/renewable energy/traditional mechanisms for household usage and agricultural production in the village.
- Average size (minimum and maximum) of rice farmland owned, cultivated, and left fallowed. Type of rice cultivation, seed (s) selected, number of cultivations per year, and average rice/other produce yield per hectare per cultivation (minimum and maximum).
- Current situation of land ownership, including residential land, and cultivation area
- Current situation of market and market prices for local agricultural produce.
- Main challenges for agricultural cultivation as well as home-gardening.
- Primary and secondary livelihood challenges
- Occurrence and type of diseases by season, quality of health care treatment services in the area or nearby places, etc.
- Issues and current situation of disaster risk reduction/climate change in the community, level of vulnerability and priority for project intervention
- Suggestions for climate resilient livelihoods and climate smart agriculture to be considered by the project.

P-LINK
People's Livelihoods Initiative through water-energy-food Nexus in the MEKONG Region

Ministry of Science and ICT

United Nations
Office for South-South Cooperation

MEKONG INSTITUTE

STEPI SCIENCE AND TECHNOLOGY POLICY INSTITUTE

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

LAO PDR NATIONAL PILOT- BASIC SURVEY

"Harmonization of the national climate and water monitoring system in Lao PDR:
A case study in Xebangfai river basin to enhance local flood early warning system (FEWS) in Nakio Village, Mahaxay District, Khammouane Province"

Background

The "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. Also known as the RoK-UNOSSC Facility (Phase 3)/P-LINK, the project takes integrative and multi-sectoral approaches in the application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation (SS & TrC) modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea (ROK), and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) and will enlist the support of other UN Agencies.

In addition to knowledge generation, advisory services, and multi-sectoral platform among the four countries, the project will carry out national technology pilots in each country. Following a series of regional and national consultations, a national pilot entitled, "Harmonization of the national climate and water monitoring system in Lao PDR: A case study in Xebangfai river basin to enhance local flood forecasting and earning warning system (FFEWS) in Nakio Village, Mahaxay District, Khammouane Province[1]. The country's pilot is divided into two components as follows:

- National level (Vientiane): Facilitate harmonization of existing national data centre and situational room to strengthen centralized water management of the country; and
- Local level (Nakio village, Mahaxay District, Khammouane Province): Provide the most suitable Local Flood Early Warning System (LFEWS) to empower local community with real-time, pertinent flood related information (disaster preparedness and mitigation) as well as ensure real-time data sharing and monitoring of weather and water situation with central system.

[1]Khammoune is a province located in central part of Lao PDR with an area of 16,315km^2 total population of 433,570 as of 2020 (2020 National Census Report). The province is divided into 10 districts.

The 18 months pilot is expected to roll out in the first quarter of 2024.

The background and baseline information of the national level pilot work will be based on the preliminary materials[2] shared by the Lao National Mekong Committee Secretariat (LMNCS) and the MRCS. The national pilot will focus on providing advisory services and technical support to strengthen integrated coordination of monitoring and disaster management of the Ministry of Energy and Mine (MEM), Ministry of Natural Resources and Environment (MONRE) and the Department of Meteorology and Hydrology (DMH) under MONRE. In particular, the pilot will work closely with LNMCS and MONRE to develop centralized database system to assist integrated water management and timely decision-making. The detailed technical framework and solution will be shared with LNMCS and MRCS following a technical assessment by ROK experts.

In parallel, the local pilot will focus on design, installation and usage of a Local Flood Early Warning System (LFEWS) for Nakio village, which aims to build community resilience to cope with climate induced disasters as well facilitate agricultural management *(Annex 1: Technology Proposal for Nakio village)*. Furthermore, the installed LFWES will be linked with the harmonized national situation and monitoring system.

In this background, the Project Team would like to better understand present situation in Nakio village, Mahaxay District, Khammouane Province including beneficiaries and village facilities that will be benefitted by the pilot. The Project Team will liaise with the VNMCS to hire one/two local expert(s) to conduct the basic survey.

Proposed National Pilot Indicators and measurement methods[3]

Objective to measure	What to measure (Component, Element)	Indicators	How to measure
1. Strengthened WEF Security	Improvement of WEF consumption and production	① Quantity of Water Consumption/Proportion of Household accessible to clean water, ~~② Proportion of Renewable Clean Water, ③ Proportions of renewable energy of total electricity,~~ ④ agricultural productivity ⑤ Women's labor input on WEF production	• National, provincial, district, village statistics and database by officials (MONRE, MAF) • Lao Women's Union at provincial level
	Damage from flood disaster per year	① Number of death and injury, ② Loss of livestock, ③ Property loss	• National, provincial, district, village statistics and database by official (MLSW, MAF)
2. Employment and Poverty (income level)	Jobs created	① Employment on Facility installed and/or related, ② Women's employment (# and %)	• National, provincial, district, village statistics and database by officials (MLSW) • Lao Women's Union at provincial level

[2] PHETTHANY,VIPHANOU/MRC. 2021. Assessment of the National Flood and Drought Forecasting Centre – National Needs Assessment Report for Lao PDR. AND Lao PDR's National Pilot Project (Coordination Monitoring Centre)- PPT.
[3] Indicators prepared by STEPI incorporating Laotian delegations' inputs and feedback during the 1st Regional TOT.

	Agricultural profit	① Income from agriculture per annual work unit ② Number of agriculture products for sale	• National, provincial, district, village statistics and database by officials (MAF: PAFO and DAFO)
3. Developing Solutions	Technology application	① Facility installed and operated ② Technology knowledge shared and transferred	• National, provincial, district, village statistics and database by official (MONRE, MEM, MAF)
	Policy adoption	① WEF Nexus Policy established by central or local government[4]	• National, provincial, district, village statistics and database by official (MONRE, MEM, MAF)

*blue notes: inputs from Cambodian delegation

Purpose of the Survey

- To take stock of the current situation of water, energy and food management in identified pilot site, Nakio village, Mahaxay District, Khammouane Province to set specific baseline data related to social, economic, environment, and policy aspects prior to the application of proposed technology solution. It will require both quantitative and qualitative data collection and analysis.
- To identify project scope, specific target beneficiaries and capacity building needs in the pilot site as well as finetune the pilot design.
- To facilitate and propose measurement of pilot indicators to monitor impact of the project related to social, economic, environment and policy.
- To provide basic information to community members and engaged national and local stakeholders about the pilot in order to enable them to have a role in establishing working groups to implement, monitor and manage the project before and after the installation of the new technology and capacity building activities.
- To coordinate efforts between government officials at national and local levels in the installation of the technology in the pilot site.

Scope of Work

- Primary and secondary data collection (both quantitative and qualitative)
- Survey the current status of facilities, equipment and system

Duration

- Around 1-2 workdays (depending on travel time to pilot site)

Budget

- Maximum USD 2,000

[4] Govt. stakeholders understand the WEF nexus policy and considers it a priority and intends to invest continuously. Coordination between the central government and Local-level decision-making will determine how trade-offs and synergies in the WEF nexus are implemented. The capacities of local government organisations and decision-makers need to be strengthened to enhance their capacity to adopt nexus approaches and coordinate vertically.

Local Expert Contract Modality

- Via STEPI

Target Respondents

- Local government (Mahaxay District, Khammouane Province)
- Community leaders and members of Nakio village

Assessed Topics

- National/Local policy frameworks related to water, energy and food management
- Local demographic information about general info about Nakio village (population, households, income level, age groups, gender, climate, wet/dry seasons, land size)
- Community governance/groups (agriculture/fishery cooperatives)
- Main source of economy (e.g. agriculture, major produce)
- Water supply/management information (e.g. monthly consumption amount, cost per unit)
- Electricity accessibility/alternative energy source, main usage (e.g. household, agriculture)
- Technical profile and cost of existing facilities used for food, water and energy supply as well as local flood early warning system (LFEWS)
- Coping, mitigation and adaptation mechanisms for climate induced disasters (floods, droughts, etc.) such as early warning system, evacuation measures, local government support arrangements
- Impact of server weather conditions (especially to most vulnerable groups including elderly, disabled, women and children)
- Food security
- Household status (e.g. female-headed vs. male-headed HHs, HHs with disability and/or more dependents)
- Households operating mono-cropping and those involved in integrated farming systems and /or multi-cropping practices,
- Level of household dependence on livestock raising for either household consumption and /or selling
- Level of household dependence on water supply for both household consumption and agricultural production
- Level of household dependence on electricity/renewable energy for household consumption and agricultural production

BASIC SURVEY REFERENCE MATERIALS

I. GUIDING QUESTIONS FOR KEY INFORMANT INTERVIEW (e.g. major, community leaders, etc.)

Date:	Time:
Interviewer's name:	Position:
Village:	Commune:

- Please provide basic demographic information of Nakio village in terms of
  - Climate characteristics (dry/wet season, floods/droughts, etc.)
  - # Population (gender, age groups)
  - # Household (household type such as female/male headed, size)
  - Community governance structure
  - Main source of income (agriculture, fishery, factory, migrant workers) and average income level
  - # of mobile users
  - Community early warning system for natural/man-made disasters
- What are current local economic drivers and livelihood situations in the locality over the last five years?
- When are the dry and wet seasons of Nakio village?
- Does the community have a local flood early warning system/facility/mechanism in place?
- How/where/how long do community members evacuate during the wet season, if required?
- Can you please share a severe unprecedent weather crisis (flash floods/drought)? How did it impact your household and community (physical and financial loss)? How much time and financial resources did it take for the community recovery and reconstruction? Any reflections and lessons learnt from these events (consequences faced by most vulnerable community members such as elderly, disabled, women and children)?
- Is there a disaster management guideline and plan for the community? Does the community organize regular mock drills/evacuation trainings? Any financial or training support provided by the provincial or national government?
- What is the average quantity of water consumption of the Nakio village per quarter/year?
- What percentage/# of the households have access to clean water?
- Is there any community facility for water supply? How is water distributed to each household? What is the price of water per unit (cm^3)? How is the water usage bill collected?
- How many water supply facilities are there in Nakio village commune? How much did the commune invest to install these facilities? For example, what is the size of the existing water tank facility? What are the specific components/equipment of this facility? What was the installation price? Is there any maintenance fee per month?
- In your opinion, what is the extent of local communities' capacity (technical, financial, governance) in terms of livelihood improvement and climate change adaption particularly related to water, energy (renewable) and food management and security?
- What climate change adaption would you like to see happen in your locality? Do you have any suggestion or recommendation for improving the community livelihood and also responding to climate change?
- Does your district/commune follow any national/local policy on integrated management of water, energy and food?

II. GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSION

- Village's name where FGD conducted.
- Date and time for FGD conduct.
- Number of participants and discussants involved. Enclose the attendance list to the report.
- Occupations of villagers (established members and common villagers) and percentage of villagers involved in each occupation.
- Current situation of community early warning system including training and facilities provided by the local and national government, if any? Any intervention and support provided by local community leaders, civil society or associations (farmers/women)?
- Current situation of water access and consumption, including main water sources for household use and agricultural production in the village. What is the monthly water usage expense on average? How does your household get water supply, is it from the community water tank or via surface water from the river?
- Current situation of energy access and consumption, including main source of electricity/renewable energy/traditional mechanisms for household usage and agricultural production in the village.
- Average size (minimum and maximum) of rice farmland owned, cultivated, and left fallowed. Type of rice cultivation, seed (s) selected, number of cultivations per year, and average rice/other produce yield per hectare per cultivation (minimum and maximum).
- Current situation of land ownership, including residential land, and cultivation area
- Current situation of market and market prices for local agricultural produce.
- Main challenges for agricultural cultivation as well as home-gardening.
- Primary and secondary livelihood challenges
- Occurrence and type of diseases by season, quality of health care treatment services in the area or nearby places, etc.
- Issues and current situation of disaster risk reduction/climate change in the community, level of vulnerability and priority for project intervention
- Suggestions for climate resilient livelihoods and climate smart agriculture to be considered by the project.

P-LINK
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Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

THALAND NATIONAL PILOT- BASIC SURVEY

"Increasing the Efficiency of Tap Water System in Moo 1,2 and 3
in Bung Khla Sub-district, Bueng Kan Province, Thailand"

Background

The "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. Also known as the RoK-UNOSSC Facility (Phase 3)/P-LINK, the project takes integrative and multi-sectoral approaches in the application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation (SS & TrC) modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea (ROK), and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) and will enlist the support of other UN Agencies.

In addition to knowledge generation, advisory services, and multi-sectoral platform, the project will carry out national technology pilots in the four participating countries. Following a series of regional and national consultations, a national pilot entitled, "Increasing the Efficiency of Tap Water System in Moo[1]1,2 and 3 in Bung Khla Sub-district, Bueng Kan Province[2]" will be implemented in Thailand. Covering mainly water and energy aspects of the Nexus, the pilot aims enhance access to clean water by using renewable energy. The pilot will introduce a Smart Water Management (SWM) initiative tailored to the local challenges including high water loss, increasing demand for water with rising population, and limited technical expertise on integrated water management *(Annex 1: Technology Proposal)*. The 18 months pilot is expected to roll out in the first quarter of 2024.

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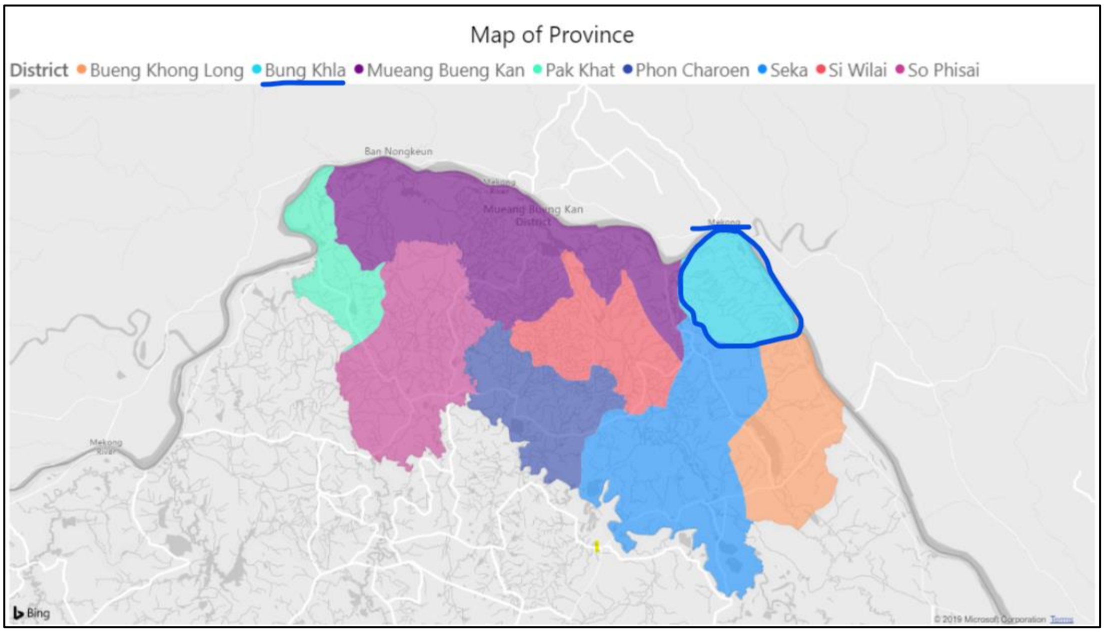
[1]Moo refers to abbreviated word for Mooban, which refers to village (moo meaning "group" bahn meaning "house" mooban = village), Source ONWR/TNMCS

[2]Stung Treng is a province located in Northeast of Thailand with geographical area of 4,003km^2 total population of 424,091 as of 2019 (2019 National Census Report). The province is divided into 8 districts that are further classified into 53 subdistricts (tambon) and 615 villages (mooban).

As one of the 8 districts of Bueng Kan Province, Bung Khla has a total area of 243.6 km2 and population of 13,037[3]. It is located on a bank of the Mekong with a prime agricultural area neighboring (Refer to Figure 1). The district is divided into three sub-districts (Bung Khla, Nong Doen and Khok Kwan) that are further classified into 25 villages. Bung Khla Subdstrict is divided into 9 administrative villages (moobans) with a total population of 5,216 people[4]. According to the data provided by TNMCS/ONWR, there are total of 943 households and 2,365 people in three Moos of Bung Khla (Table 1) that would host the national pilot.

Figure 1: Location of Bung Khla Sub-district, Bueng Kan Province



Source: Buengkan Provincial Labor Office, Government of Thailand.

Table 1: Identified Pilot Sites and number of households and population

Village (Moo)	# of Households	Population
Moo 1	268	614
Moo 2	476	1,202
Moo 3	190	546
Total	934	2,365

Source: ONWR/Bung Khla Sub-district Administrative Organization (SAO)

In this background, the Project Team would like to better understand present situation of three Moos in Bung Khla Sub-district including beneficiaries and village facilities that will be benefitted by the pilot. The Project Team will liaise with the Thailand National Mekong Committee Secretariat (TNMCS)/Office of National Water Resources (ONWR) to conduct the basic survey through Bung Khla Sub-district Administrative Organization (SAO).

3 "Population statistics 2010". Department of Provincial Administration

4 "Population statistics 2020" (in Thai). Department of Provincial Administration

Proposed National Pilot Indicators and measurement methods[5]

Objective to measure	What to measure (Component, Element)	Indicators	How to measure
1. Strengthened WEF Security	Improvement of WEF consumption and production	① Quantity of Water Consumption/Proportion of Household accessible to clean water, ② Quantity of Water leakage	① Number of people with access to clean water ② Proportion of electricity usage
	~~Damage from flood disaster per year~~	~~① Number of death and injury, ② Loss of livestock, ③ Property loss~~	
2. Employment and Poverty (income level)	Jobs created	~~① Employment on Facility installed and/or related, ② Women's employment (# and %)~~	
	Agricultural profit	~~① Income from agriculture per annual work unit ② Number of agriculture products for sale~~	
3. Developing Solutions	Technology application	① Facility installed and operated ② Technology knowledge shared and transferred	① Number of people with access to sharing knowledge with key persons
	~~Policy adoption~~	~~① WEF Nexus Policy established by central or local government[6]~~	..

*blue notes: inputs from Thai delegation

Purpose of the Survey

- To take stock of the current situation of water, energy and food management in identified pilot site, three Moos in Bung Khla subdistrict to set specific baseline data related to social, economic, environment, and policy aspects prior to the application of proposed technology solution. It will require both quantitative and qualitative data collection and analysis.
- To identify project scope, specific target beneficiaries and capacity building needs in the pilot site as well as finetune the pilot design.
- To facilitate and propose measurement of pilot indicators to monitor impact of the project related to social, economic, environment and policy.
- To provide basic information to community members and engaged national and local stakeholders about the pilot in order to enable them to have a role in establishing working groups to implement, monitor and manage the project before and after the installation of the new technology and capacity building activities.
- To coordinate efforts between government officials at national and local levels in the installation of the technology in the pilot site.

[5] Indicators prepared by STEPI incorporating Cambodia delegations' inputs and feedback during the 1st Regional TOT.

[6] Govt. stakeholders understand the WEF nexus policy and considers it a priority and intends to invest continuously. Coordination between the central government and Local-level decision-making will determine how trade-offs and synergies in the WEF nexus are implemented. The capacities of local government organisations and decision-makers need to be strengthened to enhance their capacity to adopt nexus approaches and coordinate vertically.

Scope of Work

- Primary and secondary data collection (both quantitative and qualitative)
- Survey the current status of facilities, equipment and system

Duration

- Around 1-2 workdays (depending on travel time to pilot site)

Local Experts

- Thailand National Mekong Committee Secretariat (TNMCS)/Office of National Water Resources (ONWR) and
- Bung Khla Sub-district Administrative Organization (SAO).

Target Respondents

- Bung Khla Sub-district Administrative Organization (SAO)
- Community leaders and members of Moo 1, 2 and 3

Assessed Topics

- National/Local policy frameworks related to water, energy and food management
- Local demographic information about general info about Moo 1, 2 and 3 of Bung Khla Sub-district (population, households, income level, age groups, gender, climate, wet/dry seasons, land size)
- Community governance/groups (agriculture/fishery cooperatives)
- Main source of economy (e.g. agriculture, major produce)
- Water supply/management information (e.g. monthly consumption amount, cost per unit)
- Electricity accessibility/alternative energy source, main usage (e.g. household, agriculture)
- Technical profile and cost of existing facilities used for food, water and energy supply
- Food security
- Household status (e.g. female-headed vs. male-headed HHs, HHs with disability and/or more dependents)
- Households operating mono-cropping and those involved in integrated farming systems and /or multi-cropping practices,
- Level of household dependence on livestock raising for either household consumption and /or selling
- Level of household dependence on water supply for both household consumption and agricultural production
- Level of household dependence on electricity/renewable energy for household consumption and agricultural production

BASIC SURVEY REFERENCE MATERIALS

I. GUIDING QUESTIONS FOR KEY INFORMANT INTERVIEW (e.g. major, community leaders, etc.)

Date: Time:
Interviewer's name: Position:
Village/Moo:

- Please provide basic demographic information of Moo #1, #2 and #3 in terms of
  - Climate characteristics (dry/wet season, floods/droughts, etc.)
  - # Population (gender, age groups)
  - # Household (household type such as female/male headed, size)
  - Community governance structure
  - Main source of income
  - # of mobile users

- What are current local economic drivers/livelihood situations in the locality over the last five years?

- What is the electrical power usage (kWh) in Moo #1, #2 and #3?

Month	Site	Power usage (kWh)	Power bill (Baht)
2023.6	Moo 1		
	Moo 2		
	Moo 3		
2023.7	Moo 1		
	Moo 2		
	Moo 3		
2023.8	Moo 1		
	Moo 2		
	Moo 3		

- What percentage/# of the households have access to clean water?

- Please provide number of water users/customers in each Moo:

Site	Population	Number of households	Number of water customers
Moo 1	614	268	
Moo 2	1,202	476	
Moo 3	546	190	

- What is the quantity of water consumption of the Moo #1, #2 and #3 per quarter/year?
  *For example:

Month	Site	Produced amount (㎥)	Billed amount (㎥)
2023.6	Moo 1		
	Moo 2		
	Moo 3		
2023.7	Moo 1		
	Moo 2		
	Moo 3		
2023.8	Moo 1		
	Moo 2		
	Moo 3		

- Is there any community facility for water supply? How is water distributed to each household? What is the price of water per unit (cm^3)?

Items	Unit
Water price/tariff	THB / ㎥
One year income as of 2022	THB
One year billed water amount as of 2022	㎥

- How is the water usage bill collected?
  - Number of water meter reading workers:
  - Who do the water meter reading:
  - How to pay for the water meter reading workers:
  - All information in water bill sheet:
    - Name
    - Address
    - Others *(please specify)*
  - Customer information *(in an excel file)*

- How many water supply facilities are there in Moo #1, #2 and #3? How much did the subdistrict invest to install these facilities? For example, what is the size of the existing water tank facility? What are the specific components/equipment of this facility? What was the installation price? Is there any maintenance fee per month?

  Please complete/verify the items below.

  A. <u>Water treatment plant information (Moo 1,2,3)</u>

  - Capacity : XX ㎥/day
  - Type: Rapid filtration
  - Type of coagulant: Alum
  - Daily amount of coagulant injection: XXX Liters
  - Type of disinfectant: HOCL

- Daily amount of disinfectant injection: XXX Liters
- How often execute a back wash process?
- How is the backwashed water treated?
- How often replace the filtration sand?
- How often check water quality (Turbidity, pH, Residual chlorine):
- Volume of treated water tank : XXX ㎥/tank × 2 tanks
- Height of elevation tank: 30 m

B. <u>Intak pump information (Moo 1)</u>

- Capacity: 1 ~ 1,100 Liter/min
- Head: 21.2 ~ 8.9 m
- Voltage: 220 V
- Power: 2.2 kW
- Hz: 50 Hz

C. <u>Intak pump information (Moo 2,3</u>)

- Capacity: 200 ~ 500 Liter/min
- Head: 41.2~18.2 m
- Shut off head: 43 m
- Voltage: 220 V
- Power: 3.7 kW
- Hz: 50 Hz

D. Booster pump information (Moo 1,2,3)

- Capacity: 200 ~ 500 Liter/min
- Head: 41.2~18.2 m
- Shut off head: 43 m
- Voltage: 220 V
- Power: 3.7 kW
- Hz: 50 Hz

E. Pipe network information: *Please provide GIS or CAD File*

- In your opinion, what is the extent of local government and communities' capacity (technical, financial, governance) in terms of livelihood improvement and climate change adaption particularly related to water, energy (renewable) and food management and security?

  For example, what is the organizational structure and staff members in charge of water management in Bung Khla Sub-district?

Department	Position	Name	Job description	Email

(Please list all personnel related to water services)

- What climate change adaption would you like to see happen in your locality? Do you have any suggestion or recommendation for improving the community livelihood and also responding to climate change?

- Does your sub-district follow any national/local policy on integrated management of water, energy and food?

II. GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSION

- Village's name where FGD conducted.
- Date and time for FGD conduct.
- Number of participants and discussants involved. Enclose the attendance list to the report.
- Occupations of villagers (established members and common villagers) and percentage of villagers involved in each occupation.
- Current situation of water access and consumption, including main water sources for household use and agricultural production in the village. What is the monthly water usage expense on average? How does your household get water supply, is it from the community water tank or via surface water from the river?
- Current situation of energy access and consumption, including main source of electricity/renewable energy/traditional mechanisms for household usage and agricultural production in the village.
- Average size (minimum and maximum) of rice farmland owned, cultivated, and left fallowed. Type of rice cultivation, seed (s) selected, number of cultivations per year, and average rice/other produce yield per hectare per cultivation (minimum and maximum).
- Current situation of land ownership, including residential land, and cultivation area
- Current situation of market and market prices for local agricultural produce.
- Main challenges for agricultural cultivation as well as home-gardening.
- Primary and secondary livelihood challenges
- Occurrence and type of diseases by season, quality of health care treatment services in the area or nearby places, etc.
- Issues and current situation of disaster risk reduction/climate change in the community, level of vulnerability and priority for project intervention
- Suggestions for climate resilient livelihoods and climate smart agriculture to be considered by the project.

as of 8 November 2023

P-LINK
People's Livelihoods Initiative through water-energy-food Nexus in the MEKONG Region

Triangular Cooperation Project on Sustainable Development in the Lower Mekong Basin based on the Water-Energy-Food (WEF) Nexus; RoK-UNOSSC Facility Phase 3/P-LINK

VIET NAM NATIONAL PILOT- BASIC SURVEY

"Improvement of Livelihood through the Application of Water-Energy-Food (WEF) Nexus Approach in the Mekong Delta of Viet Nam"

Background

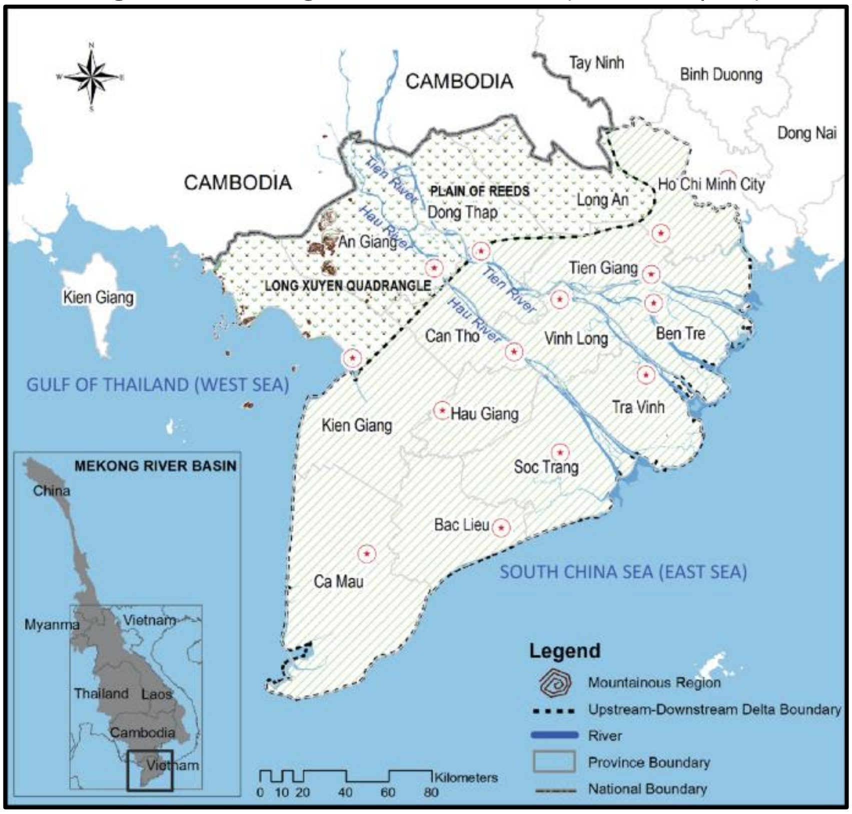
The "Triangular Cooperation Project on Sustainable Development in the Lower Mekong River Basin based on the Water-Energy-Food (WEF) Nexus" (2021-2025) aims to strengthen access to water, food and energy for vulnerable communities living in the Lower Mekong Basin (Cambodia, Lao PDR, Thailand, and Viet Nam) through strengthening development approaches and management in these sectors. Also known as the RoK-UNOSSC Facility (Phase 3)/P-LINK, the project takes integrative and multi-sectoral approaches in the application of highly demanded technologies on water, energy and food to improve the livelihoods of the people based on South-South and triangular cooperation (SS & TrC) modalities. The five-year project is supported by the Ministry of Science and ICT, Republic of Korea (ROK), and the UN Office for South-South Cooperation (UNOSSC) leads the project in partnership with other institutions including the Mekong River Commission Secretariat (MRCS), Mekong Institute (MI) and the Science and Technology Policy Institute (STEPI) and will enlist the support of other UN Agencies.

In addition to knowledge generation, advisory services, and multi-sectoral platform, the project will carry out national technology pilots in the four participating countries. Following a series of regional and national technical consultations, a national pilot entitled, "Improvement of Livelihood through the Application of Water-Energy-Food (WEF) Nexus Approach in the Mekong Delta of Viet Nam" will be implemented in Con Linh (Linh Island), Thanh Phu Dong Commune, Giong Trom District, Ben Tré Province, Viet Nam to tackle adverse impacts of salinity. Covering all three elements of the Nexus, the pilot aims to enhance access to clean water for household usage by providing a WEF nexusing desalination system[1] of saline groundwater to be generated by renewable (solar) energy. The appropriate desalination system also consists of a brine reuse system that can be used for shrimp farming tailored to the local needs *(Annex 1: Technology Proposal)*. The 18 months pilot is expected to roll out in the first quarter of 2024.

[1] Comprised of water component (entire desalination system), energy component (solar energy system) and food component (brine reuse system in shrimp farming)

As of the 13 provinces in the Mekong Delta of Viet Nam, Ben Tré Province is situated in the Southeastern part of the country, located between Tien Giang Province to the North and Vinh Long and Tra Vinh Provinces to the Southwest (Figure 1). It has a geographical area of 2,394.6 km^2 with an estimated total population of 1,469,004[2] as of 2018. It is considered as the top five most densely populated area[3]. The province is subdivided into 8 districts[4] and 1 provincial city, Ben Tré.

Figure 1: Mekong Delta of Viet Nam (Southern part)



Source: Van Tho, N. (2022).[5]

Well known for paddy production, coconut cultivation and shrimp farming, agriculture, fishery and forestry are the key economic drivers of Ben Tré. Industrial and commercial sectors such as infrastructure construction and tourism also contribute to the local economy.

Climate change has already been adversely impacting the livelihood of communities in the Mekong Delta. Ben Tre Province is facing severe salinity from sea water intrusion affecting their agriculture and fishery production due to sea level rise and soil erosion. In this background, the Project Team would like to better understand present situation in Con Linh (Linh Island), Thanh Phu Dong Commune, Giong Trom District, Ben Tré Province district including beneficiaries and village facilities that will be benefitted by the pilot. The Project Team will liaise with the Viet Nam National Mekong Committee (VNMC) to hire one/two local expert(s) to conduct the basic survey.

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[2]ERIA Study team (2022), 'Analysis of the Viet Nam Population Database', in Reiko Hayashi and Osuke Komazawa, Health and Long-term Care Information in Ageing Asia. ERIA Research Project Report FY2022 No. 07, Jakarta: ERIA, pp.50-78.

[3]Ben Tre Provincial Government. http://english.bentre.gov.vn/node/279

[4]Ba Tri, Bình Đại, Châu Thành, Chợ Lách, Giồng Trôm, Mỏ Cày Bắc, Mỏ Cày Nam, and Thạnh Phú.

[5]Salinity Intrusion in the Vietnamese Mekong Delta, a Threat: Possible Causes, Effects on People's Life and Production, and Temporary Solutions and Adaptable Strategies. In: Jeon, HY. (eds) Sustainable Development of Water and Environment. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-07500-1_1

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Proposed National Pilot Indicators and measurement methods[6]

Objective to measure	What to measure (Component, Element)	Indicators	How to measure
1. Strengthened WEF Security	Improvement of WEF consumption and production	① Quantity of Water Consumption/Proportion of Household accessible to clean water, ② Proportion of Renewable Clean Water, ③ Proportions of renewable energy of total electricity, ④ agricultural productivity *(Monitoring productivity would require longer monitoring period for data collection. VN pilot project does not have strong direct linkage to agricultural production)* ~~⑤ Women's labor input on WEF production~~ (realistically difficult)	Provincial/ District/ Commune Govt. level
	Damage from flood disaster per year	① Number of death and injury, ② Loss of livestock, ③ Property loss	
2. Employment and Poverty (income level)	Jobs created	① Employment on Facility installed and/or related, ② Women's ~~employment (# and %)~~ participation number/rate in capacity building training events ~~③ Poverty reduction rate~~	
	Agricultural profit	~~① Income from agriculture per annual work unit, ② Number of agriculture products for sale~~ (similar to above, difficult to measure, slightly different focus area, shrimp farming)	
3. Developing Solutions	Technology application	① Facility installed and operated ② Technology knowledge shared and transferred	Project Team
	Policy adoption	① WEF Nexus Policy established by central or local government[7] *(if to monitor productivity)*	

*blue notes: inputs from Vietnamese delegation

Purpose of the Survey

- To take stock of the current situation of water, energy and food management in identified pilot site, Con Linh (Linh Island), Thanh Phu Dong Commune, Giong Trom District to set specific baseline data related to social, economic, environment, and policy aspects prior to the application of proposed technology solution. It will require both quantitative and qualitative data collection and analysis.
- To identify project scope, specific target beneficiaries and capacity building needs in the pilot site as well as finetune the pilot design.
- To facilitate and propose measurement of pilot indicators to monitor impact of the project related to social, economic, environment and policy.
- To provide basic information to community members and engaged national and local stakeholders about the pilot in order to enable them to have a role in establishing working groups to implement, monitor and manage the project before and after the installation of the new technology and capacity building activities.
- To coordinate efforts between government officials at national and local levels in the installation of the technology in the pilot site.

[6] Indicators prepared by STEPI incorporating Vietnamese delegations' inputs and feedback during the 1st Regional TOT.

[7] Govt. stakeholders understand the WEF nexus policy and considers it a priority and intends to invest continuously. Coordination between the central government and Local-level decision-making will determine how trade-offs and synergies in the WEF nexus are implemented. The capacities of local government organisations and decision-makers need to be strengthened to enhance their capacity to adopt nexus approaches and coordinate vertically.

Scope of Work

- Primary and secondary data collection (both quantitative and qualitative)
- Survey the current status of facilities, equipment and system

Duration

- Around 1-2 workdays (depending on travel time to pilot site)

Budget

- Maximum USD 2,000

Local Expert Contract Modality

- Via STEPI

Target Respondents

- Local government (Ben Tré Province, Giong Trom District, People's Committee)
- Community leaders and members of Con Linh (Linh Island), Thanh Phu Dong Commune

Assessed Topics

- National/Local policy frameworks related to water, energy and food management
- Local demographic information about general info about Ben Tré Province, Giong Trom District and Thanh Phu Dong Commune (Con Linh)
  - E.g.) Population, households, income level, age groups, gender, climate, wet/dry seasons, land size
- Community governance/groups (agriculture/fishery cooperatives)
- Main source of economy (e.g. agriculture, major produce)
- Water supply/management information (e.g. monthly consumption amount, cost per unit)
- Electricity accessibility/alternative energy source, main usage (e.g. household, agriculture)
- Technical profile and cost of existing facilities used for food, water and energy supply
- Food security
- Household status (e.g. female-headed vs. male-headed HHs, HHs with disability and/or more dependents)
- Households operating agricultural/fish farming and those involved in integrated farming systems and /or multi-cropping practices,
- Level of household dependence on livestock raising for either household consumption and /or selling
- Level of household dependence on water supply for both household consumption and Agricultural/fishery production
- Level of household dependence on electricity/renewable energy for household consumption and agricultural/fishery production

BASIC SURVEY REFERENCE MATERIALS

I. GUIDING QUESTIONS FOR KEY INFORMANT INTERVIEW (e.g. major, community leaders, etc.)

Date: Time:
Interviewer's name: Position:
Village:

- Please provide basic demographic information of Con Linh, Thanh Phu Dong Commune in terms of
  - Climate characteristics (dry/wet season, floods/droughts, etc.)
  - # Population (gender, age groups)
  - # Household (household type such as female/male headed, size)
  - Community governance structure
  - Main source of income
  - # of mobile users
- What are current local economic drives and livelihood situations in the locality over the last five years?
- What is the average quantity of electricity consumption (kWh) of the Con Linh, Thanh Phu Dong Commune per quarter/year? How do you generate electricity (e.g. public grid)? Are there alternative energy sources (renewable such as wind, solar) used by the Commune? What are the main usages of these electricity/energy (e.g. to watch TV, charge mobile, generate water supply)?
- What is the average quantity of water consumption of the Con Linh, Thanh Phu Dong Commune per quarter/year?
- What percentage/# of the households have access to clean water?
- Is there any community facility for water supply? How is water distributed to each household? What is the price of water per unit (cm^3)? How is the water usage bill collected?
- How many public/private water supply facilities are there in Con Linh, Thanh Phu Dong Commune? How much did the commune invest to install these facilities? For example, what is the size of the existing water tank facility? What are the specific components/equipment of this facility? What was the installation price? Is there any maintenance fee per month?
- How do you source water for your paddy/shrimp farming? (*if appliable)*
- In your opinion, what is the extent of local communities' capacity (technical, financial, governance) in terms of livelihood improvement and climate change adaption particularly related to water, energy (renewable) and food management and security?

- What climate change adaption would you like to see happen in your locality? Do you have any suggestion or recommendation for improving the community livelihood and also responding to climate change?
- Does your district/commune follow any national/local policy on integrated management of water, energy and food?

II. GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSION

- Village's name where FGD conducted.
- Date and time for FGD conduct.
- Number of participants and discussants involved. Enclose the attendance list to the report.
- Occupations of villagers (established members and common villagers) and percentage of villagers involved in each occupation.
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- Main challenges for agricultural/fishery (shrimp) cultivation as well as home-gardening.
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