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W-FLR ROADMAP FOR THE WATERSHED OF MAROLAMBO, MADAGASCAR

Reviewed by Forests4Future, GIZ

SIWI

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Acronyms

AFR100 – African Forest Landscape Restoration Initiative
FLR – Forest and Landscape Restoration
GCF – Green Climate Fund
GEF – Global Environment Facility
GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit
MEDD – Ministry of the Environment and Sustainable Development
M&E – Monitoring and Evaluation
NAP – National Adaptation Plan
NbS – Nature-based Solution
NDC – National Determined Contributions
NGO – Non-Governmental Organization
PES – Payment for Ecosystem Services
SIWI – Stockholm International Water Institute
W-FLR – Water-smart Forest and Landscape Restoration

Preface

This report is part of the SIWI program for the development and piloting of the Water-smart Forest and Landscape Restoration (W-FLR) Tool, supported by GIZ. We acknowledge the invaluable support and collaboration of GIZ Madagascar's Forests4Future project team, whose commitment and cooperation were essential to the successful execution of this pilot in the watershed of Marolambo.

We also express our sincere appreciation to the stakeholders who participated in the W-FLR workshop in Majunga concerning the Marolambo watershed. Their expertise, insights, and feedback were critical in validating and refining the W-FLR case study, ensuring its relevance, practicality, and ownership.

The W-FLR Roadmap for the watershed of Marolambo is the final output of a comprehensive process that began with the development of the W-FLR Tool, a pioneering effort by SIWI, supported by GIZ and SIDA. The Roadmap was developed as part of a pilot program conducted in three countries, including Madagascar, where the watershed of Marolambo was selected as the pilot site due to its critical environmental and socio-economic significance.

The Roadmap development process was structured into two main phases: the Preparatory Phase and the Workshop Phase. During the Preparatory Phase, SIWI technical team conducted an extensive analysis based on publicly available information, focusing on three key modules: assessing the need for W-FLR at national and sub-national levels, mapping risks and opportunities for water ecosystem services, and identifying and engaging key stakeholders. The outcomes of this phase were compiled into a draft preparatory phase report, which served as the foundation for the subsequent Workshop Phase.

During the Workshop Phase, the stakeholders were first consulted to validate and adjust, if necessary, the preparatory work. Further, the participants were asked to identify priority actions for water-smart FLR, related to policy integration, capacity development, and implementation. The Roadmap incorporates the feedback and recommendations from these consultations, ensuring that it reflects the needs and priorities of the stakeholders involved. It includes priority actions and indicators that were identified during and post-workshop by participants and the W-FLR team, respectively.

The W-FLR Roadmap provides a Strategic Actions Plan for analysis-planning-implementing water-smart FLR in the watershed of Marolambo. It outlines a clear path forward for enhancing ecosystem services, improving livelihoods, and building resilience to climate change. The successful implementation of this Roadmap will depend on continued collaboration among all stakeholders, ensuring that the vision of a sustainable and resilient Marolambo watershed becomes a reality.

Executive summary

The W-FLR Roadmap for the Marolambo watershed provides a strategic framework to pair water-related ecosystem services with FLR initiatives. Expanding on conventional FLR approaches highlights the critical link between forest and water management to bolster ecosystem services and climate resilience. Developed collaboratively, this Roadmap integrates input from key stakeholders such as local authorities, non-governmental organizations (NGOs), and community committees.

The W-FLR Roadmap provides a strategic response to critical environmental challenges compromising both regional ecosystems and local community welfare. This integrated approach advances sustainable land and water management by prioritizing the restoration of vital water ecosystem services in the watershed that sustains five villages: Andranomendevy, Andranomiantra, Ampasikabe, Maroabolay, and Betsivakia. Key services—including freshwater supply, nutrient cycling, soil regeneration, and biodiversity maintenance—are declining due to pollution, land degradation, and deforestation. Such deterioration undermines water regulation, agricultural output, and climate adaptability. To counter these threats, the roadmap champions water-smart FLR initiatives that synergize forest and water management practices.

Components of the W-FLR Roadmap

The W-FLR Roadmap presents priority actions structured around three strategic components. First, policy mainstreaming focuses on incorporating water-related ecosystem services into national and regional policies while aligning with climate initiatives such as National Determined Contributions (NDCs) and National Adaptation Plan (NAP). Second, capacity development aims to strengthen stakeholders' technical expertise through targeted training and knowledge-sharing platforms. Third, implementation focuses on concrete interventions, including pilot projects for water-smart FLR, development of early warning systems for water-related risks, or again the promotion of participatory approaches on the ground.

The Roadmap highlights stakeholder engagement as a critical success factor for water-smart FLR implementation. Through a systematic stakeholder mapping process, it identifies and categorizes key actors across all levels - from local communities to national authorities, including government agencies, NGOs, private sector representatives, and civil society groups. The framework proposes tailored engagement strategies to promote inclusive participation and maintain long-term stakeholder commitment. This participatory methodology serves as a foundation for achieving sustainable restoration outcomes.

The W-FLR Roadmap's Strategic Actions Plan serves as a diagnostic tool to evaluate system readiness for water-smart FLR implementation. It pinpoints critical actions across three dimensions: policy mainstreaming, capacity development, and field-level implementation. The plan emphasizes the need to harmonize water and landscape governance frameworks while fostering cross-sectoral collaboration to maximize restoration outcomes. Furthermore, it recommends strengthening monitoring, evaluation, and adaptive management systems to ensure measurable progress and continuous improvement.

The Marolambo Watershed W-FLR Roadmap highlights multiple pathways for advancing water-smart restoration initiatives. While socio-economic pressures, deforestation, and climate variability present significant challenges, these can be mitigated through Madagascar's supportive policy frameworks. The Roadmap identifies international financing opportunities, Payment for Ecosystem Services (PES) schemes, and robust community participation as key enablers for expanding restoration activities. Through a strategic approach to these obstacles and capitalization on existing resources, the plan establishes a sustainable framework for restoring vital water-related ecosystem services throughout the Marolambo watershed.

The outcomes collected during the workshop with local stakeholders at Majunga will be supplemented by the inputs of national stakeholders during a training at the national scale, which is planned to take place during the AFR100 Annual Partner Meeting in 2026.

Recommendations

The W-FLR Roadmap's successful execution depends on several prioritized recommendations.

First, there is a need to promote policy reforms that explicitly support water-smart FLR, developing coherent strategies that integrate seamlessly with national planning frameworks to enable effective restoration.

Second, capacity development must focus on tailored training programs for local stakeholders—communities, government agencies, and NGOs—complemented by knowledge-exchange platforms to foster collaborative learning and dissemination of knowledge. Equally critical is expanding stakeholder engagement by actively including marginalized groups like indigenous communities and women's organizations, while cultivating private sector alliances to bolster restoration efforts.

Third, initial restoration efforts should prioritize high-impact zones with urgent ecological needs, employing adaptive management principles to enable real-time adjustments and iterative enhancements. Concurrently, strengthened monitoring and evaluation (M&E) systems must be implemented, featuring participatory frameworks that engage local communities in data collection and analysis to ensure both accountability and enduring stewardship.

Lastly, a critical priority identified by GIZ during the W-FLR training session is securing sustainable financing. This requires mobilizing resources from both international climate funds and national funding sources, while simultaneously developing community-based funding mechanisms to empower local restoration efforts such as PES. Such diversified financial strategies will guarantee the sustainability of water-smart FLR interventions across the Marolambo watershed.

1. Introduction to the watershed of Marolambo

The W-FLR approach marks a paradigm shift in restoration practices by explicitly integrating water considerations into forest and landscape management. This innovative framework acknowledges water's fundamental role in sustaining both ecosystems and local livelihoods. The Marolambo watershed - an ecologically vital and socio-economically strategic area - was chosen as Madagascar's testing ground for implementing the W-FLR methodology.

SIWI's technical team performed an in-depth assessment of the watershed by analyzing publicly available datasets, scientific studies, reports and statistical information to evaluate ecological conditions and pinpoint major areas of improvement. The study specifically examined: (1) the watershed's biophysical attributes, (2) the socio-economic value of its ecosystems, and (3) pressing environmental threats. The resulting analysis offers a systematic evaluation of degradation drivers, restoration constraints, and strategic opportunities for implementing water-smart restoration approaches.

1.1 Geographic and environmental characteristics

The Marolambo watershed, situated in the Boeny region (North-West of Madagascar), encompasses a rich, diverse and ecologically significant landscape (MEDD, IUCN & GIZ, 2020). The watershed is located in the south-west side of the Andranomandevy village and benefits Anjiaja, and Tsaramandroso villages (Figure 1).

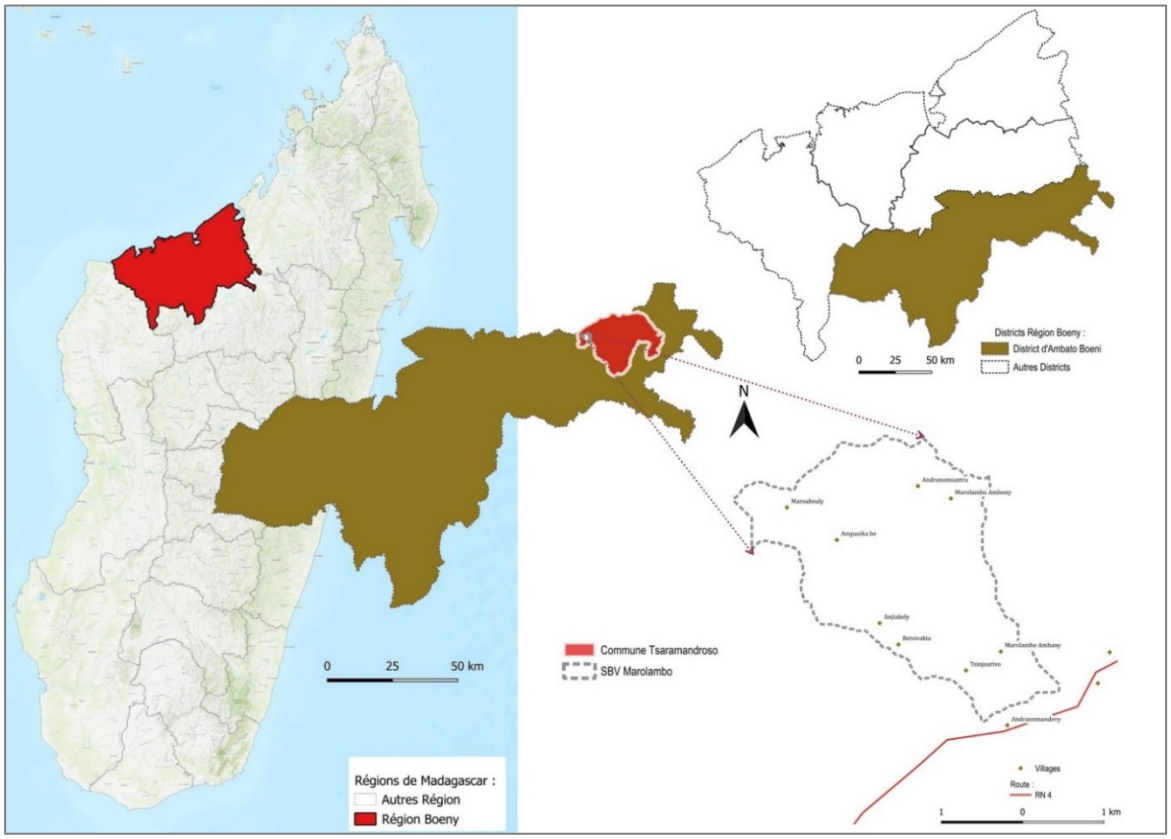

Figure 1: Map showing the selected focus area: Boeny region (GIZ Madagascar)

The watershed serves as a daily water source for 1,750 people, encompassing 649.12 hectares with 141.22 hectares currently in degraded condition (21.8% of the total area). It is sustained by Ampasikabe and Andranomiantra groundwater sources that gather in Ambalambato (GIZ & NIRAS, [In preparation]).

The watershed exhibits a humid tropical climate with marked seasonal variability - heavy rains (900-1200 mm) from November to April, followed by an arid dry season (1-20 mm) from May to October. Temperatures vary between 28°-36°C in the rainy season and 23°-27°C in the dry season. The extreme hydrological contrast presents distinct water resource management challenges. The watershed serves as a critical hydrological resource, supporting regional agricultural production, livestock husbandry, potable water systems, sanitation infrastructure, and domestic water needs. Seasonal droughts regularly compromise both crop yields and animal productivity due to water scarcity.

1.2 Key drivers of forest and landscape degradation

According to the MEOR study of 2020, the area of degraded forest increased by one-third between 2000 and 2017 (Figure 2).

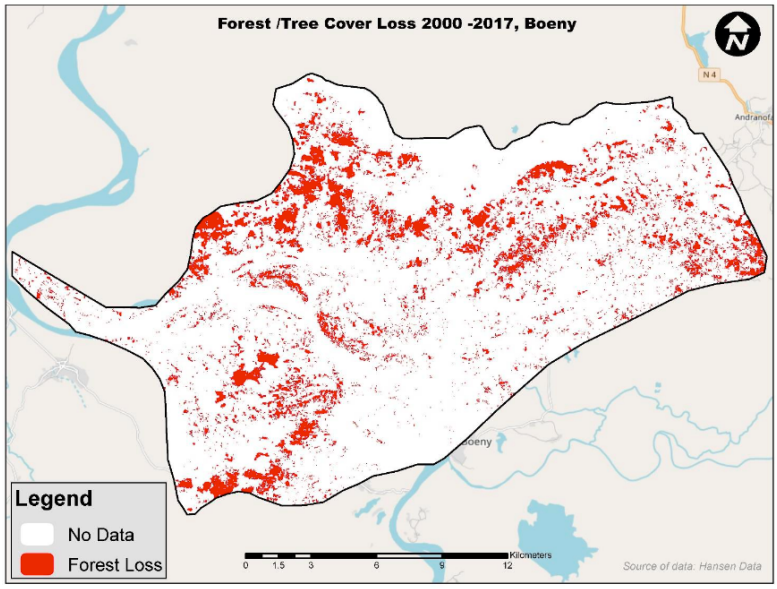

Figure 2: Forest loss, 2000-2017, Boeny. Source: ROAM study, 2020.

The Marolambo watershed faces multiple interconnected drivers of environmental degradation, with the most significant being (World Bank, 2022; MEDD, IUCN & GIZ, 2020; GIZ & NIRAS):

- **Agriculture** through unsustainable practices, including intensive use of soil, lack of crop rotation, chemical overuse, informal construction of weir dams, slash-and-burn ("Tavy"), and land-clearing. These methods exacerbate topsoil depletion, agrochemical pollution, and accelerate erosion and hydrological system disruption.

- **Logging** for charcoal production, timber, and fuelwood, both legally and illegally. The population highly depends on fuelwood for cooking, which causes degradation and severe health and productivity issues, especially for women and children.

- **Poverty and population growth** are causing unsustainable pressure on natural resources and are underlying drivers of unsustainable practices and deforestation.

- **Ineffective forest and water governance and poor law enforcement** are also fundamental drivers of landscape degradation. This includes inadequate implementation of forest policies, management plans, and protected area frameworks, undermining conservation efforts on the ground. Some policies are incoherent and lack clarity regarding FLR. There is a lack of a water management system and structure in Marolambo, leading to water conflicts in the village of Andranomandevy.

- **Climate change** is driving increased climatic variability, manifested through more frequent and intense flood events, droughts, heat waves, cyclones, and disruptions to traditional rainfall patterns.

1.3 Potential barriers to forest and landscape restoration

The Marolambo watershed faces several challenges in implementing a water-smart FLR. During the W-FLR workshop, local stakeholders identified and discussed the following key barriers:

- **Legal**: Misunderstanding and lack of clarity on FLR laws, with poor enforcement.

- **Institutional**: The government's extension system has difficulties reaching remote and inaccessible villages. The roles and responsibilities of traditional chiefs in FLR projects merit further clarification. Inadequate water resource governance.

- **Environmental**: Variable and unreliable water availability, water pollution from fertilizers, and degraded soil fertility.

- **Anthropogenic activities**: Cooking using firewood due to a lack of alternative energies, land pollution due to sugarcane factories, poverty, and population growth.

- **Land rights**: The poor land governance (lack of knowledge of the law, low land certification rate of 12%) and growing conflicts (land grabbing, uncontrolled migration) discourage investment in landscape restoration. The population, which is insufficiently informed about the value of land titles, lacks motivation to secure its land.

- **Inadequate access to information**: Communities lack access to knowledge on restoration, assisted natural regeneration, conservation agriculture, and climate-smart agriculture.

- **Socio-cultural**: Women and young people remain marginalized in decision-making, with low public participation and cultural barriers (gender roles, exclusion from land ownership, 34% lower income). Traditional norms and beliefs limit their autonomy, even though they are the primary users of resources.

- **Socio-economic**: Economic limitations constrain local adoption of sustainable land management, as agricultural-dependent households (the primary livelihood source) face productivity trade-offs during restoration transitions. This economic reality fosters resistance when viable income alternatives are absent.

- **Financial**: Lack of financial support for restoration activities, including access to investments, loans, credit, and subsidies.

- **Monitoring and Evaluation**: M&E methods for FLR lack harmonization and coherent integration of water across sectors, each responsible entity follows its own guidelines.

1.4 Enabling opportunities for forest and landscape restoration

The Marolambo watershed presents multiple opportunities for enabling effective water-smart FLR implementation, as identified through our analysis. Building on existing FLR foundations, these include supportive policy frameworks, innovative financing mechanisms, proven community engagement approaches, and synergies with global restoration initiatives - all of which can overcome current implementation challenges.

Enabling Policies and Frameworks

- **Alignment with global restoration initiatives**, such as the Bonn Challenge and the AFR100 support national and regional restoration efforts, such as Madagascar's national objective of restoring 4 million ha of degraded land within the AFR100 initiative. Engagement in these initiatives offers access to international expertise, funding, and recognition, enhancing the effectiveness of restoration efforts.
- Existence of an M&E system at the Ministry of the Environment and Sustainable Development (MEDD) level.

Institutional and policy support

- **Watershed management committee** supporting local communities.

Financial Mechanisms

- **PES schemes:** Climate funds as well as funding from the private sector can support the implementation of PES mechanisms, which can, ultimately, generate financial incentives and create sustainable financing models for restoration projects. PES models will increase the livelihoods of the providers by benefiting from a series of payments from the beneficiaries for the ecosystem services provided.

Environmental and Ecological Conditions

- **Existing forest resources:** The Marolambo watershed harbors dense tropical forests with high biodiversity. The area features sacred community forests that blend cultural significance with ecological value, preserving unique habitats. Selective logging and sustainable agroforestry practices demonstrate potential for balanced resource use and effective restoration projects (MEDD, IUCN & GIZ, 2020).

- **Ecosystem services:** The Marolambo watershed provides numerous ecosystem services such as carbon storage, water regulation, and soil conservation, where these natural assets make Marolambo both ecologically significant and economically vital for local communities (MEDD, IUCN & GIZ, 2020). Strategic integration of ecosystem services into restoration planning amplifies water-smart FLR impacts by visibly linking ecological recovery to community benefits. Such alignment ensures congruence between on-ground restoration outcomes and the core principles of both FLR and water-smart FLR frameworks.

Community Engagement and Capacity Development

- **Local knowledge and traditional practices**: Local communities have a strong reliance on forests for their supply of medicinal resources, food, timber, and charcoal, which provides opportunities to restore and conserve these species.
- **Innovative technologies**, such as GIS and remote sensing, can enhance the effectiveness of restoration initiatives by mapping the most suitable areas as well as elaborating potential scenarios.

2. Water-related ecosystem services integration into policy and practice

The GIZ team conducted a comprehensive assessment of water-related ecosystem services in the Marolambo watershed with support from SIWI. They combined scientific knowledge with their on-the-ground experience, applying a holistic lens to understand the interlinkages within the socio-ecological landscape. To ensure robustness, the preliminary findings were validated via a workshop with local stakeholders in Majunga, thereby grounding the scientific analysis in local insight.

2.1 Water-related ecosystem services risk analysis

Effective water-smart FLR starts with a thorough assessment of current water-related ecosystem processes (Table 1). This assessment reveals the degree to which water-related ecosystem services within the system boundary are at risk of decline or loss. The current status offers a baseline of functionality and indicates potential future vulnerabilities. This comprehensive perspective enables the prioritization of restoration efforts and the formulation of adaptive strategies to manage both present and future challenges. To this end, the W-FLR team has conducted a risk analysis synthesizing publicly available data, GIZ's experience, and input gathered from a stakeholder workshop.

The Marolambo watershed is experiencing significant declines across various water-related ecosystem services. The analysis demonstrates that 65% of the ecosystem processes analyzed are at high or intermediate risk within the system boundary (see Appendix 1. and summary in Table 1), underscoring the urgent need for effective water-smart FLR investments to restore ecosystem services. We note that all regulating ecosystem services are at high risk and that the majority of supporting ecosystem services are also at high risk. Conversely, all provisioning ecosystem services and the majority of cultural ecosystem services are at low risk.

Proactively mitigating these risks, especially for supporting and regulating ecosystem services, is critical to safeguarding the long-term sustainability of the watershed's ecosystem services and future restoration projects. Through a comprehensive risk assessment and management strategy, we can bolster the resilience of water-related services, thereby ensuring the enduring health and sustainability of the Marolambo watershed and its communities.

Table 1. Summary of the Water-related Ecosystem Services Risk Analysis of the Marolambo watershed. (Full table in Appendix 1. Water-related Ecosystem Services Table.)

Water-related ecosystem services	Ecosystem processes	Risks
Supporting services		
Hydrological cycle	E.g., through transpiration, recycling of precipitation, controlling water runoff, etc.	
Nutrient cycle	E.g., in the atmosphere, in soil organic matter and in soil and rock minerals.	
Soil formation/ quality	Tree roots and soil organic matter improve soil moisture and structure. High rate of organic matter in soil slows down water movement.	
Biodiversity	Water linking organisms and supporting pollen/propagule dispersal. Habitats that safeguard fisheries and biological diversity.	
Provisioning services		
Freshwater	Tree density influence groundwater recharge. Tree species and age influence water yield.	
Food and medicines	Ecosystems provide conditions for producing food / extracting medicines.	
Materials	Ecosystems provide raw materials for construction, production and fuel.	
Regulating services		
Water flow regulation	Ability of the catchment's ecosystems to regulate water flow, including water retention, streamflow regulation, and increased infiltration.	
Water purification	Catchment's natural ecosystems play a crucial role in filtering pollutants and improving water quality.	
Climate regulation	Carbon sequestration in soil, as well as in above- and below-ground vegetation. Regulation of local temperature by evapotranspiration.	
Cultural services		
Heritage / Cultural Identity	Catchment's significant cultural / spiritual value for local communities.	
Wellness, Recreation, and (Eco)tourism	The catchment offers opportunities for recreation, wellness, and ecotourism.	

3. Entry points for water-related ecosystem services in policies and plans

The Marolambo watershed is a critical zone of ecological importance with rich water resources and diverse forests. Integrating water-smart FLR into current policies is essential to combat environmental degradation, improve water-related ecosystem services, and enable sustainable land management. This analysis identifies policy entry points, assesses gaps, and proposes actionable recommendations to advance these efforts.

3.1 Mapping entry points and gaps in national/ sub-national policies and plans

Nationally Determined Contributions

Madagascar first submitted its Nationally Determined Contributions (NDC) to the UNFCCC in 2016, following the Paris Agreement. This initial commitment outlined the country's strategy to combat climate change despite its minimal contribution to global emissions. An updated, more ambitious NDC was submitted in September 2021, ahead of the COP26 conference. This revised document significantly strengthened Madagascar's climate action goals and framework. A key improvement in forestry was the move from a single sector focus to a more systemic approach, encompassing major sectors influencing/ being potentially affected by the forest sector. The updated NDC sets quantified targets for both mitigation and adaptation, enhancing its transparency and measurability (Ministère de l'Environnement et du Développement Durable, 2022).

Its core objectives are centered on adaptation, aiming to build resilience for its highly vulnerable population and unique ecosystems. Priorities include protecting coastlines, improving food security through sustainable agriculture, and ensuring water resource management. A major focus remains on reducing deforestation and promoting reforestation to safeguard its biodiversity.

The NDC also emphasizes integrating gender equality and social inclusion into all climate actions. However, achieving these objectives is heavily contingent on accessing substantial financial resources, technology transfer, and capacity-building support from the international community. Madagascar's NDC represents a critical roadmap for its sustainable development, directly linking climate action to poverty reduction and the preservation of its natural heritage.

The NDC would need to adopt a more systemic ecosystem services approach for FLR activities to encompass all related ecosystem services. Water-related ecosystem services could be integrated into both mitigation and adaptation objectives. The forest-water nexus is a critical component to foster mainstreaming water into FLR initiatives, which should explicitly be stipulated in the NDC. Water management is key for effective climate action and must be central to all adaptation and mitigation measures.

National Adaptation Plan

Madagascar's UNFCCC NAP, launched in 2021, represents a critical roadmap for one of the world's most climate-vulnerable nations. The plan acknowledges that adaptation is not merely a sectoral issue but a prerequisite for national development and resilience (Ministère de l'Environnement et du Développement Durable, 2021).

Water security is a central pillar of the NAP, reflecting its significant role in resilience and economic activity. The plan's water-related objectives are comprehensive, focusing on integrated water resources management (IWRM), the rehabilitation of hydraulic infrastructure, and the promotion of efficient irrigation techniques to safeguard and improve agricultural yields. A key highlight is its emphasis on protecting and restoring critical water sources, which directly introduces the indispensable forest-water nexus. The NAP explicitly recognizes that Madagascar's unique forests, including its rainforests and dry

deciduous ecosystems, are vital regulators of the hydrological cycle (Ministère de l'Environnement et du Développement Durable, 2021).

By linking forest conservation and restoration directly to water security and agricultural productivity, it moves beyond siloed interventions. However, the profound challenge lies in implementation. Translating this visionary framework into tangible action requires unprecedented coordination between the agriculture, environment, and water sectors, alongside significant international finance and robust community engagement.

3.2 The best entry points for water-smart FLR in policies and plans

The review of the NDC and PNA of Madagascar identified promising entry points for water-smart FLR interventions in the watershed of Marolambo. Adopting holistic approaches, with an emphasis on water-related ecosystem services, in FLR initiatives and policies is critical due to their important potential benefits. As stressed in the PNA, financial resource mobilisation remains a strong aspect to focus on to implement a national framework able to apply for and use international and national funds with rigorous and transparent management.

A reliable and harmonized monitoring and evaluation system would also enable a stronger tracking process of interventions. Leveraging these entry points will require multi-stakeholder and cross-cutting approaches to, ultimately, strengthen policy implementation, bolster institutional capacity, and successfully mainstream water-smart FLR principles into national and sub-national planning. This integrated approach will enable Madagascar to synergistically achieve its environmental and development goals, securing the long-term sustainability of water and forest resources.

Most of the local stakeholders from the workshop were unfamiliar with the reviewed national documents, which hindered their ability to enrich these plans and to access climate finance. A workshop with national stakeholders would also bring valuable input to this case study regarding the improvement of water-smart FLR policies and plans.

4. Key sectors and stakeholders to involve and influence

A key component of the W-FLR case study is the analysis and engagement of key sectors and stakeholders. The W-FLR analysis must align with FLR efforts and relevant initiatives and processes. The engagement of key stakeholders is a prerequisite for a successful workshop and for ensuring the long-term sustainability of water-smart FLR interventions.

The preparatory phase enabled GIZ and SIWI to identify relevant stakeholders from diverse sectors, including forestry, water, fishing, and agriculture, and across various categories, such as authorities, NGOs, community-based organizations, academic institutions, and the private sector. The analysis considered stakeholders at national, regional and local levels, which could potentially be involved in policy mainstreaming, capacity development, and implementation. Then, these stakeholders were grouped based on their influence, interest, and overall relevance.

GIZ proceeded with a selective process to invite local stakeholders with valuable knowledge (Table 2). Stakeholders represented regional entities, basin organizations, committees, associations, local communities, and NGOs. As part of the W-FLR methodology, during the selection process, special focus was invested in ensuring inclusivity and representativeness of vulnerable groups, including women, youth, and indigenous peoples.

Table 2: Organizations represented at the local W-FLR workshop in Majunga

N°	Stakeholder categories	Sectors	Number of participants
1	Regional entities	Region/Department for the Promotion of Economic Potential (DVPE)	1
2		Region/Department of Environmental Protection and Ecology in the Boeny Region (DPEE)	1
3	Basin organizations	Regional Directorate for Environment and Sustainable Development (DREDD)/ Interregional Forest Services	1
4		Regional Directorate for Environment and Sustainable Development (DREDD)/ Interregional Environmental Services	1
5		Regional Directorate for Water, Sanitation, and Hygiene (DREAH)	1
6		Regional Directorate of Agriculture and Livestock/ Regional Rural Engineering Service (SGR)	1
7	Regional Offices/Councils	Madagascar Ankarafantsika National Park	1
8	District authorities and their technical agencies (e.g., agricultural extension)	Agriculture and Livestock District of Ambatoboeny	1
9	Local associations, committees, and communities	Ambatoboeny Environment and Forestry District	1
10		KMTA VOI Reforestation Team in collaboration with Tany Meva	1
11		Miaradia Women's Association (rice farming and market gardening)	2
12		Tsimanavaka Andranomandevy Women's Association	1
13		Fikambanan'ny Tanora Andranomandevy (Youth Association)	1
14		Representative of displaced migrants (Marolambo, Andranomandevy)	1
15		Marolambo sub-watershed Management Committee	2
16		Bemangoraka sub-watershed Management Committee	2
17		Group of Members for Reforestation in Andranomandevy (GAR)	1
18		Antsika Fish Farming Association	1

N°	Stakeholder categories	Sectors	Number of participants
19		Water Resource Committee (Komity Loharano in the Fokontany Andranomandevy)	1
20	Ministry of Homeland Affairs	Rural Commune of Tsaramandroso	1
21	Private sectors	Andranomandevy Mango Value Chain Cooperative	1
22		MIHARY Company (Raffia)	1
23	ONG Locale	NGO Mazava	1
24	Projets/Programmes	GIZ Paddi	1
25		GIZ Forests4Future Madagascar	5
26		GIZ ProMic	1
27		PLAE/KfW	1
30		SIWI	2
		TOTAL	**36**

5. Priority actions and indicators of W-FLR

The W-FLR Roadmap for the Marolambo watershed is grounded on the compiled results of the W-FLR workshop in Majunga. Developed through a collaborative process where workshop participants identified, analyzed, and prioritized key actions related to policy mainstreaming, capacity development and implementation, the W-FLR Roadmap provides a strategy that bridges the gap between analysis (preparatory phase), planning (workshop phase) and tangible actions.

5.1 Process of identifying water-smart FLR priority actions

The formulation of the W-FLR Priority Actions followed a structured, multi-step process:

1. **Pre-workshop analysis by the GIZ and SIWI Technical Team**: The W-FLR Tool methodology requires the development of key preparatory analysis based on relevant available data and official documents. It encompasses (1) the identification of the system boundary, (2) the assessment of water-related ecosystem services at risk, (3) the identification of entry points for water-smart FLR in national policies and plans, and (4) a stakeholder analysis.
2. **Stakeholder verification and validation:** The W-FLR Tool is designed to produce a stakeholder-driven Roadmap, rooted in the active involvement of local stakeholders. Workshop participants reviewed the preparatory results and enriched them with their own experiences and observations.
3. **Development and prioritization of actions**: Following the revision of the preparatory work, workshop participants defined a set of priority actions to integrate water-smart principles into all FLR interventions within the system boundary. These actions will contribute to addressing water-related ecosystem services at high risk of being reduced or lost within the system boundary.

5.2 W-FLR priority actions of local stakeholders in the Marolambo watershed

The priority action framework covers three levels: policy mainstreaming, capacity development, and implementation on the ground. The workshop participants identified actions for water-smart FLR under each pillar. In total, 28 actions were identified. Through a voting process, participants subsequently prioritized actions to determine the most urgent needs in water-smart FLR (Figure 3) based on the water-related ecosystem at risk and the potential barriers of FLR. The GIZ and SIWI technical team reformulated and rearranged some actions to ensure coherence and exactitude of the information and alignment with the water-smart FLR principles (explained in the section "5.5. Ensuring alignment with water-smart FLR"). In figure 3, actions that were given very low priority were not integrated.

The results demonstrate that the local stakeholders assessed that W-FLR actions concerning capacity development are the most urgent, especially linked to inputs and materials needed for water related reforestation and restoration activities. They also prioritized implementation on the ground e.g. construction of a dam to store and provide irrigation during periods of low flow. Other priority actions include strengthening the capacity of basin officers regarding the enforcement of the Water Code and the implementation of reforestation activities to protect water sources.

5.3 W-FLR Roadmap Strategic Actions Plan

The W-FLR Roadmap Strategic Action Plan (Table 3) summarizes and gathers the priority actions identified by local stakeholders. The GIZ and SIWI technical team reviewed, curated, supplemented, and adjusted the prioritization of actions to ensure relevance and coherence with the water-smart FLR principles (as explained in the "Alignment with water-smart FLR" section).

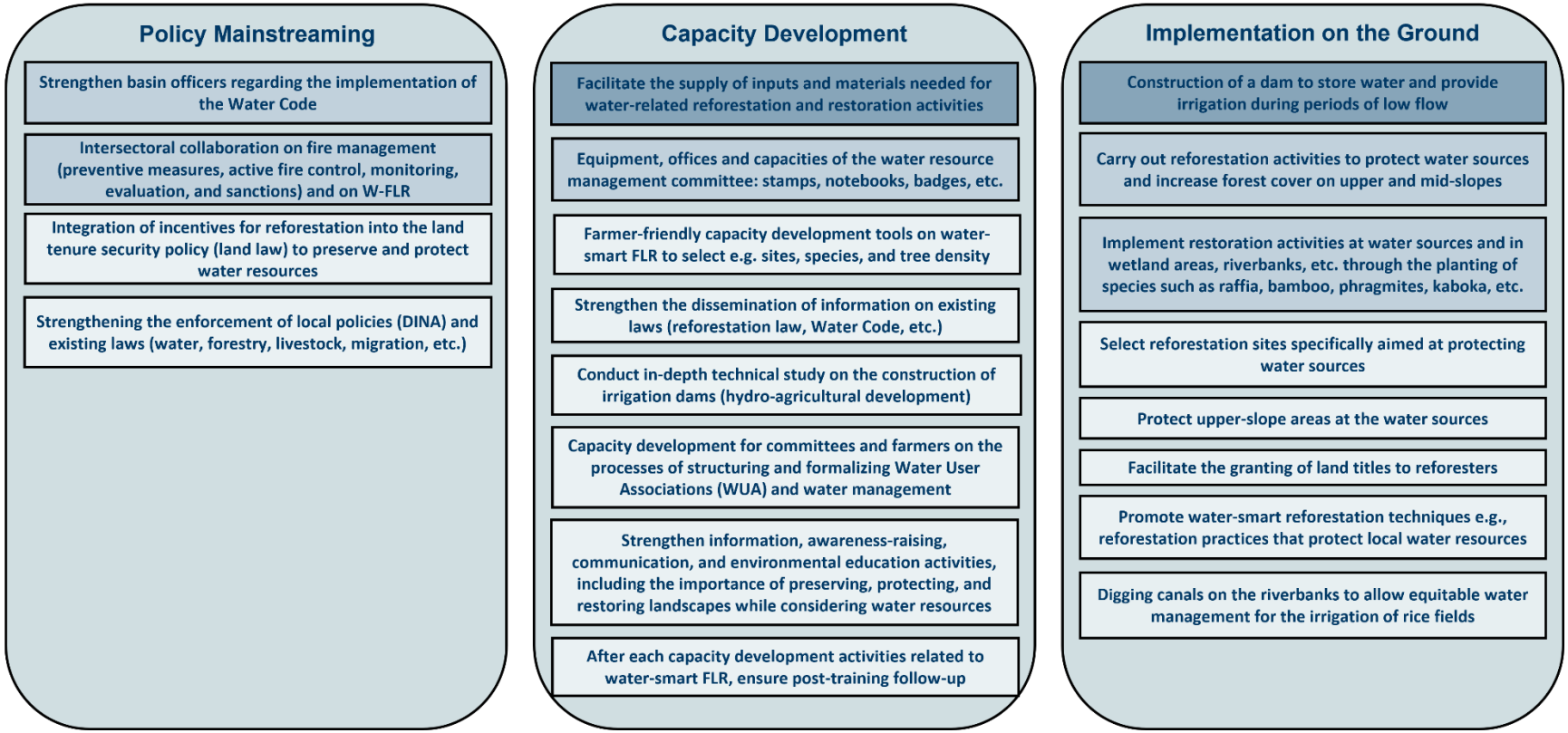

Figure 3: W-FLR Priority Actions identified by local stakeholders in the micro-basin of Marolambo

Table 3: The W-FLR Roadmap Strategic Actions Plan

Task 4a: Priority actions	POLICY MAINSTREAMING OF WATER-SMART FLR	CAPACITY DEVELOPMENT IN WATER-SMART FLR	IMPLEMENTATION OF WATER-SMART FLR	TASK 5A: INDICATORS
1. Improve access to inputs and materials to support and implement water-smart FLR		Strengthening of the capacity of local actors to implement W-FLR through training in the use of inputs and materials.	Provision of equipment and inputs to local actors directly involved in the implementation of water-smart FLR activities, including monitoring equipment and advanced measuring instruments.	Number of inputs and materials delivered Number of trainings Number of local actors involved
2. Strengthen the implementation of laws, policies and land rights relevant to water-smart FLR	Strengthen basin officers regarding the implementation of the Water Code. Integration of restoration incentives to preserve and protect water resources in the land tenure security policy. Strengthening the enforcement of local policies (DINA) and existing laws (water, forestry, livestock, migration, etc.). Facilitate the granting of land titles to smallholder reforestation practitioners.	Strengthen the dissemination of information on existing laws (reforestation law, water code, etc.) through workshops and training sessions.		Number of laws enforced Number of land titles granted to smallholder foresters Area allocated to smallholder foresters Number of basin officers trained Number of workshops/trainings

3. Promote cross-sectoral collaboration on water-smart FLR	Facilitate cross-sectoral collaboration on water-smart FLR related activities e.g. fire management (preventive measures, awareness raising about fire impacts, monitoring, assessment and sanctions).	Trainings, platforms, cross-site exchanges, communication and knowledge exchange workshops to learn and share practical lessons from existing projects. Capacity development of committees and local stakeholders on establishment of water user associations (WUAs) and water management.	Identification of best practices from existing initiatives and empowerment of local practitioners to replicate and adapt them to new areas. Hands-on field training with experienced locals/technicians Facilitate participatory approaches on the ground, such as multi-stakeholder dialogues, development of joint action plans, and participatory monitoring systems.	No. cross-sectoral meetings No. stakeholders trained No. on-site trainings held Knowledge products created No. of participatory approaches No. of joint action plans signed
4. Water-smart FLR and conservation for source water protection		Trainings on farmer-friendly capacity development tools on water-smart FLR, to select appropriate sites, species and tree density. Strengthen information, awareness-raising, communication, and environmental education activities on the importance of preserving, protecting and restoring landscapes while considering water resources.	Implementation of water-smart FLR to protect water sources and to increase forest cover in the upper (tectonia, Mangarahara, etc.) and mid-slope (albizia L., Acacia Auriculoformis, etc.) areas. Restoration activities at the water sources and in wetlands areas, riverbanks, etc. through the planting of species such as raffia, bamboo, phragmite, kaboka, etc. Protection of upper-slope areas at the water sources.	No. of projects successfully implemented Area under water-smart FLR management Area under protection Improved water quality Improved water quantity Increased biodiversity

5. Establish a monitoring and evaluation (M&E) framework for water-smart FLR initiatives	Promote a standardized M&E framework in water-smart FLR in national and subnational policies.	Develop the capacity of stakeholders through trainings, workshops, manuals and toolkits on the application of the water-smart FLR monitoring and evaluation framework (data collection, analysis and reporting).	Monitor and evaluate water-smart FLR projects using the established framework and implement a participatory M&E system for the adaptive management of water-smart FLR initiatives. Implementation of biological erosion control measures (vetiver, sisal planting, etc.) and mechanical measures (infiltration ditches, weirs, etc.). Use of technologies to monitor reforestation and restoration activities: e.g. drones, SAP (fireflood).	No. of national or subnational policies adopting the M&E framework No. of stakeholders trained No. of project sites monitored Improved water quality Improved water quantity Increased biodiversity
6. Promote the construction of water storage facilities	Provide financial and technical support to build new infrastructure linking with water-smart FLR activities (e.g. tree nurseries).	Training on integrated and sustainable water management. In-depth technical study on the construction of irrigation dams (hydro-agricultural development).	Construction of a dam to store water and provide irrigation during periods of low flow. Digging of canals on the left and right banks to allow equitable water management for the irrigation of rice fields	Number of training courses Financial assistance provided to construction of water-storage facilities Number of local actors involved

5.4 Analysis of identified priority actions

The W-FLR Roadmap Strategic Action Plan highlights the following priority areas for successful implementation of water-smart FLR initiatives. The priority areas are ranked and listed with the most urgent action first.

1. **Improve access to inputs and materials to support and implement water-smart FLR.** It is crucial to facilitate the supply of water-related restoration inputs and equipment, such as measuring instruments, and tree seedlings, while providing training related to their use. Ultimately, this will ensure impacts at scale, longevity and sustainability of water-smart FLR interventions. With 65% of water-related ecosystem services at high or intermediate risk, participants mentioned that restoration requires concrete inputs and equipment for implementation on the ground, such as: tree seeds and seedlings, tree nursery equipment, etc. Developing additional seed supply points or tree seedling nurseries in strategic locations in remote areas could improve local access.

2. **Strengthen the implementation of laws, policies and land rights relevant to water-smart FLR**. To enhance implementation of the Water Code, it is important to increase the number of controls by basin officers. Strengthening the integration of water-smart FLR initiatives in local policies (DINA), and existing laws (water, forestry, livestock, migration, etc.) is key to building a solid vision at the political level. Law enforcement is also instrumental for effective implementation. Participants also underscored the need for incentives to preserve and protect water resources in the land tenure security policy and a facilitated granting process of land titles to reforestation practitioners. Lastly, they stressed improving the dissemination of legal texts and incentives for restoration to increase their awareness. These actions will improve water and landscape governance and secure land rights to enable communities to sustainably engage in the implementation of water-smart FLR.

3. **Promote cross-sectoral collaboration on water-smart FLR**. Coherent and effective water-smart FLR is achieved through cross-sectoral collaboration. Integrating water issues within other relevant policies ensures a synergistic approach and promotes informed decisions, supporting ecosystem health and water security. Multi-stakeholder workshops, consultation platforms, inter-site exchanges, joint trainings and the structuring of Water User Associations (WUAs), which are the most appropriate ones in Madagascar and in the focus area, nurture the harmonization of practices, agreements, and the co-creation of shared action plans. This action supports policy mainstreaming and capacity development, promoting mutual learning, the dissemination of best practices and more participatory approaches. Furthermore, practical field training is important to empower local communities and foster ownership.

4. **Water-smart FLR and conservation for source water protection.** This action responds to the high risks with severely degraded ecosystem services linked to water regulation, purification, soil formation and biodiversity. Restoration in the upper hill source water area is therefore needed, using drought-tolerant species (raffia, bamboo, phragmite, kaboka, etc.) adapted to the hydrological context to improve infiltration and moisture recycling, reduce erosion and increase water availability. By targeting critical areas, this action strengthens implementation on the ground and contributes directly to the improvement of ecosystem services.

   The capacity for hydraulic redistribution varies by tree species. Mosaic restoration strategies can enhance this process, fostering mutualistic interactions that improve water availability and promote the growth of all trees. For instance, acacia and eucalyptus species, high water consumers, can be

mixed with bamboo and raffia species, known for their water retention capacity. Additionally, terrestrial moisture recycling was assessed as high risk due to the lack of dense forest in the area, presenting significant opportunities for the restoration of dense forest. While rice is the main staple food item in Madagascar, rice paddies are prone to siltation because of land degradation. Thus, restoration activities can strongly mitigate this risk by locking nutrients in the soil.

5. **Establish a monitoring and evaluation (M&E) framework for water-smart FLR initiatives.** The establishment of a standardized M&E framework in water-smart FLR, that integrates relevant national/subnational policies and is supported by training (e.g. workshops, trainings, manual, etc.) and technologies (e.g. drones, warning systems (SAPs), hydrological monitoring tools, etc.), is crucial for obtaining meaningful, comparable, and understandable outcomes. Capacity development of stakeholders through trainings, workshops, and toolkits, is fundamental for effective understanding and adequate use of the framework. The M&E framework must be co-designed together with local stakeholders and delivered in locally appropriate ways (using local languages, culturally relevant indicators, and accessible tools) to ensure relevance and accuracy, fostering a sense of ownership. Accessible M&E system enables continuous improvement and on-the-ground feedback, empowering communities to advocate for their needs and drive sustainable change. When communities can understand, value, and independently manage the M&E processes, it increases their accountability, which, ultimately, benefits all implementing bodies.

6. **Promote the construction of water storage facilities.** Participants outlined their need for a dam to store water and enable irrigation during dry periods. This was considered a high priority action. However, it does not directly focus on water-smart FLR, why the W-FLR technical team downgraded this action. Still, it can, to some extent, benefit water-smart FLR initiatives, if, for example, the water is used to irrigate tree seedlings in nurseries. Facilities such as dams and canals require in-depth feasibility and technical studies to avoid unintended consequences, and opportunities for Nature-based Solutions (NbS) as an alternative need to be investigated. Supportive policies can also facilitate access to financial and technical support to build this kind of infrastructure. Thus, this action, under the right circumstances, could offer diverse benefits such as improving water and food security, household resilience and rural economy, and create favorable conditions for integrated watershed management.

5.5 Ensuring alignment with water-smart FLR

To ensure alignment with water-smart FLR principles, the GIZ and SIWI technical team reviewed all workshop-proposed actions. The team refined those that required modifications, thereby strengthening the water-smart FLR compliance, success, and long-term sustainability of the initiatives.

Actions should focus primarily on nature-based solutions (NbS) because they offer major strategic, ecological, and economic benefits. NbS tackle the root causes of water degradation through a preventive and regenerative effect, compared to technical/"gray" solutions, which are more curative in nature. NbS also offer multiple and systemic co-benefits, compared to "gray" solutions, which are generally monofunctional. NbS are an investment in heritage that increases in value over time thanks to their profitability and resilience, whereas gray infrastructure depreciates. A NbS is co-produced with users, which strengthens local water governance and reduces the risk of conflict or abandonment. Finally, NbS should be prioritized when they are technically and socially relevant, and integrated upstream of gray projects. NbS thus constitute a resilient foundation on which gray infrastructure can be built, if necessary.

Actions must also explicitly integrate their relationship with water resource management, as this is an essential parameter to be taken into account in W-FLR. Based on these two aspects, the W-FLR team has reformulated and adjusted the prioritization of actions.

5.6 Additional priority action to consider

Building on the priority actions set by the stakeholders, the SIWI technical team recommends adding the following priority action on resource mobilization, which was also introduced at the workshop by the GIZ technical team. The SIWI technical team believes that this action will bring significant value to improve the system readiness for water-smart FLR.

Promote resource mobilization for water-smart FLR. Scaling restoration from isolated pilot projects to a sustainable, basin-wide initiative requires a strategic and diversified approach to financing. Implementing the W-FLR roadmap depends on securing layered financial streams that blend international, national, and local capital. This multi-sourced model is crucial for covering the full spectrum of costs—from initial technical assessments and capacity development to long-term maintenance and monitoring of restored areas—ensuring interventions are not only implemented but also long-term viable.

The watershed could benefit from multilateral climate finance from e.g. the Green Climate Fund (GCF) and the Global Environment Facility (GEF), which prioritize integrated approaches that deliver co-benefits for adaptation, mitigation, and biodiversity – a core strength of water-smart FLR initiatives. Additionally, partnerships with bilateral donors like GIZ or Sida can provide vital technical assistance and seed funding for initial project phases to support building robust local financial mechanisms. This includes exploring PES schemes where downstream water users invest in upstream landscape restoration, including agroforestry enterprises, and integrating water-smart FLR priorities into municipal development budgets. By empowering local stakeholders with direct access to financial tools, ownership is fostered and a self-sustaining cycle of investment could be created, ensuring that restoration continues long after external funding cycles have ended.

Alignment with global initiatives like the Bonn Challenge and AFR100 could unlock a powerful combination of funding, expertise, and recognition, thereby amplifying the success of restoration work.

Payments for Ecosystem Services

Forests4Future directed a specific request to the W-FLR Helpdesk regarding PES schemes relevant for water-smart FLR. We therefore conducted a complementary literature review, relevant for the Boeny context.

Both PES and FLR aim to improve ecosystem functions and services, although they focus on different mechanisms. FLR focuses on restoring degraded forests and landscapes to regain ecological integrity and functionality, and PES schemes can act as sustainable financing mechanisms to make FLR viable for local communities and landowners by covering costs or providing economic benefits. For example, by rewarding landholders for undertaking restoration activities that lead to improved ecosystem services (e.g., carbon sequestration, water purification, biodiversity) or paying farmers for planting native species in degraded areas because of the carbon storage or improved water quality generated, as well as their cultural and recreational value.

In Madagascar, the PES are mainly focusing on carbon (e.g. through REDD+) that incentivizes restoration of degraded lands, through carbon credits, and water. Other water-related PES initiatives are related to hydro-electric power production and potable water.

The main opportunity for F4F is to identify opportunities for watershed protection PES, funding restoration of forests upstream to secure downstream water supply, e.g. water funds. There already exists PES projects in Madagascar where communities are rewarded for managing their land in ways that improve water flow and reduce sedimentation in rivers. This benefits downstream water users, including those relying on hydropower and agriculture. For reference, see the report "Knowledge mobilization in

water and carbon pes projects implementation in Madagascar" from the IRD UMR GRED – SERENA research program.

FLR requires active participation of local communities in planning and execution. PES mechanisms can provide direct incentives for local actors to engage in restoration and thus align stakeholder interests by making restoration economically attractive.

Monitoring ecosystem services is essential for both PES and FLR, and PES can be useful in supporting monitoring of FLR outcomes. PES schemes typically require clear indicators of ecosystem service provision, which can complement FLR monitoring frameworks. If FLR is intended to restore hydrological functions, a PES related to water supply can fund and require the necessary impact monitoring.

FLR initiatives like the Bonn Challenge or UN Decade on Ecosystem Restoration can be supported by PES schemes as part of national strategies. Some countries integrate PES within their Nationally Determined Contributions (NDCs) under the Paris Agreement, often tied to restoration commitments.

Aligning PES with FLR also faces challenges, especially considering accurate valuation of ecosystem services, ensuring equity in benefit sharing and the risk of "commodifying" restoration at the expense of social or ecological priorities. It is therefore crucial to make informed decisions together with key stakeholders, especially at local scale.

Best practice 1. PES for watershed protection in Andasibe, eastern Madagascar (near the Andasibe-Mantadia National Park). Implemented by: IUCN, in collab. with local NGOs (e.g., Mitsinjo Association) and communities (Namirembe et al. 2014).

Watershed protection PES — downstream water users (e.g., the local water utility, tourism lodges) pay upstream communities to conserve and restore forested catchments that regulate water supply and reduce erosion. Payments were used to support reforestation efforts on degraded slopes that feed into water catchments supplying the local water network. Agroforestry activities and native species planting were promoted to stabilize soils, reduce sedimentation, and improve water flow consistency. Restoration focused on riparian zones and slopes critical for watershed health.

Ecosystem Services Paid For:

- Water quality and flow regulation
- Soil erosion control
- Biodiversity conservation (as co-benefit)

Local farmers received direct payments or in-kind support (e.g., seedlings, training) for engaging in restoration efforts. This resulted in improved water quality and a more reliable supply for downstream communities, including tourism operators, providing a successful demonstration of linking forest restoration with water-related services, contributing to local FLR goals.

Challenges involved lack of long-term financial sustainability, since it depended on consistent contributions from water users. The project also showed the need for stronger institutional frameworks to replicate and scale these models nationally.

Best practice 2. The Ankeniheny-Zahamena Corridor (CAZ), Eastern Madagascar
Implemented by: Conservation International and the Malagasy government + local communities (Rakotondrasoa, et al. 2020).

The PES program in CAZ was developed as part of a broader REDD+ project to protect one of Madagascar's most biodiversity-rich rainforests, which was under threat from slash-and-burn agriculture (tavy) and logging. PES revenues from carbon credits were used to support forest conservation, fund agroforestry and sustainable agriculture programs with local communities and promote reforestation and enrichment planting in degraded areas

Ecosystem Services Paid For:

- Carbon sequestration
- Biodiversity conservation
- Water regulation (indirectly)

The project helped conserve over 370,000 hectares of forest. Restoration activities focused on improving degraded lands, through community-managed agroforestry systems, and reforestation, providing alternative livelihoods to reduce deforestation pressures. The initiative was integrated with national FLR commitments under Madagascar's contribution to the Bonn Challenge and AFR100 (African Forest Landscape Restoration Initiative).

Challenges in long-term sustainable funding due to PES payments were not always regular or substantial, reflecting broader challenges with REDD+ financing globally. There were also issues in ensuring equitable benefit-sharing among local communities.

6. Summary of the system readiness for water-smart FLR

The W-FLR Roadmap outlines the readiness, across three core pillars: policy mainstreaming, capacity development, and implementation on the ground, required for the successful implementation of water-smart FLR initiatives. By evaluating the strengths, gaps, and opportunities within each pillar, the roadmap provides a comprehensive analysis of the Marolambo watershed's overall readiness for successful water-smart FLR initiatives.

Pillar 1. Policy mainstreaming of water-smart FLR

Policy mainstreaming examines the extent to which water-smart FLR is mainstreamed into existing policies and assesses the institutional framework for its execution. The focus is on diagnosing the policy environment and determining required adjustments to enable water-smart FLR.

The above analysis reveals that the overall policy readiness for W-FLR is moderate. The forest-water nexus is recognized in the UNFCCC NAP but remains a significantly underdeveloped opportunity across the broader policy landscape. Achieving a high level of readiness requires policy reforms, fostering cross-sectoral coordination, and strengthening institutional capacity for water-smart FLR.

Capacity development in water-smart FLR

Capacity development is fundamental for successful water-smart initiatives and is deeply intertwined with supportive policies. Focusing on developing capacity ensures a well-prepared and knowledgeable workforce ready to execute the necessary actions.

Based on the above analysis, the system's capacity in W-FLR is low. Important efforts must concentrate on developing the capacity of local stakeholders on institutional expertise, raising awareness on the forest-water nexus, and bridging technical skill gaps.

Implementation on the ground of water-smart FLR

Readiness for implementation addresses the preparedness to actively operationalize water-smart FLR interventions. It focuses on the availability and adequacy of financial resources, infrastructure, knowledge, and implementation mechanisms required for successful water-smart FLR projects.

The system readiness for on-the-ground water-smart FLR implementation is low. Closing this gap requires dedicated efforts in policy mainstreaming, capacity development, financial support, infrastructure, and implementation mechanisms. PES schemes were identified during the workshop as a powerful implementation mechanism which could provide sustainable financing support for water-smart FLR projects in the Marolambo watershed.

The W-FLR Roadmap delivers a Strategic Actions Plan to guide the analysis, planning, and implementation of water-smart FLR in the Marolambo watershed. Executing the recommended priority actions will substantially boost the watershed's readiness for W-FLR, advance sustainable management of forest and water resources, and support broader environmental and socio-economic goals in the region. The Roadmap emphasizes a concrete trajectory for enhancing water-related ecosystem services, improving livelihoods, and bolstering climate resilience. Its successful implementation lies in the continued collaboration of stakeholders, facilitation of access to blended financial mechanisms and the shared objective of realizing the vision of a sustainable and resilient Marolambo watershed. Lastly, the significant engagement demonstrated by local stakeholders presents a considerable opportunity for successful future implementation.

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8. Appendix

8.1 Water-related Ecosystem Services Table

Services écosystémiques	Exemples de processus écosystémiques soutenant les services écosystémiques	Tâche 1b : État actuel des processus écosystémiques liés à l'eau	Tâche 2b : Traité dans les plans et politiques pertinents
Services écosystémiques de soutien			
Soutien du cycle hydrologique	**Transpiration.** Les arbres ont un impact sur la disponibilité de l'eau en extrayant l'eau du sol ou des eaux souterraines et en l'émettant dans l'atmosphère sous forme de vapeur. Avec une gestion appropriée, ils peuvent améliorer l'humidité atmosphérique à l'échelle locale et les flux d'eau verte.		CDN, 2022 PNA, 2021
	Interception de la canopée. Le couvert forestier réduit la vitesse de chute de l'eau de pluie à la surface du sol forestier, ce qui peut réduire le ruissellement de surface et l'érosion.		PNA, 2021
	Redistribution hydraulique. Les arbres à racines profondes améliorent l'humidité du sol pendant les périodes sèches en redistribuant passivement l'eau des couches humides vers les couches sèches par l'intermédiaire de leurs racines.		
	Recyclage de l'humidité terrestre. Les forêts rechargent l'humidité atmosphérique et influencent la formation des nuages, entraînant (pompant) les flux d'humidité atmosphérique du littoral vers l'intérieur des continents, ce qui peut renforcer les précipitations à l'intérieur des terres.		
Soutien au cycle des nutriments	L'eau favorise le cycle des nutriments du sol (par exemple l'azote et le phosphore) dans les sols forestiers à partir des matières organiques (vivantes et mortes) et des minéraux présents dans les sols et les roches, ainsi que des nutriments transportés par l'eau qui s'écoule. Les racines des arbres fixent également les nutriments dans le sol, empêchant le lessivage des nutriments dans les rivières et les ruisseaux.		
Soutien à la formation et la qualité des sols	Les racines des arbres et la matière organique du sol provenant des apports de litière (par exemple, les feuilles mortes) améliorent la structure du sol, ralentissent le mouvement de l'eau et favorisent l'activité de la faune.		PNA, 2021
Soutien à la biodiversité	L'eau de forêt crée des habitats qui préservent les ressources halieutiques et la diversité biologique. L'eau qui coule dans les forêts favorise la production primaire, la		CDN, 2022

	capacité de charge et la formation de niches ; l'eau permet également la dispersion des organismes, du pollen et des propagules.		
Services écosystémiques d'approvisionnement			
Approvisionnement en eau douce potable	La forêt peut filtrer et absorber l'excès de nutriments provenant par exemple du ruissellement agricole, et la litière de feuilles, les racines et les micro-organismes du sol de la forêt piègent et décomposent les polluants.		
Approvisionnement en nourriture et en médicaments	L'eau est essentielle pour que les forêts fournissent les conditions nécessaires à la culture et à la récolte des aliments et à l'extraction de médicaments, par exemple à partir de fruits, de champignons ou d'écorces.		PNA, 2021
Approvisionnement en bois, fibres, énergie et combustible	L'eau est essentielle pour que les forêts fournissent des matériaux dérivés du bois pour la construction, la production, l'énergie et les combustibles, y compris les textiles, les biocarburants et les huiles végétales.		CDN, 2022 PNA, 2021
Services écosystémiques de régulation			
Régulation du débit d'eau	**Infiltration**. Les forêts et les arbres influencent l'entrée de l'eau dans le sol, en contrôlant le ruissellement des sols forestiers et la recharge du sol et des eaux souterraines, ce qui peut réguler l'humidité du sol et les flux hydrologiques. Dans les sols secs, les racines des arbres percent la surface dure et ouvrent des passages où l'eau peut s'infiltrer dans le sol.		PNA, 2021
	Stockage d'eau dans le tronc. Les arbres stockent l'eau, ce qui leur permet de maintenir une transpiration élevée pendant certaines périodes, même lorsque l'absorption par le sol est limitée ; cela permet aux arbres d'émettre de la vapeur sur des périodes plus longues, influençant ainsi l'humidité atmosphérique.		
Régulation du climat	**Réduire la température locale et l'évaporation du sol.** Les forêts et les arbres renvoient de l'énergie et de l'humidité dans l'atmosphère et créent des microclimats sous le couvert des arbres, refroidissant ainsi la surface de la terre et favorisant les précipitations.		PNA, 2021
	Séquestration et stockage du carbone. L'eau joue un rôle clé dans le maintien de l'absorption du carbone par les forêts et dans la préservation du carbone déjà séquestré.		PNA, 2021 CDN, 2022
Services écosystémiques culturels			

Valeur patrimoniale et identité culturelle	Les « souvenirs » liés au paysage et provenant de liens culturels passés, qui s'expriment principalement à travers les caractéristiques des paysages culturels.		
Expériences spirituelles	Lieux saints ou spirituels importants pour l'identité spirituelle ou rituelle, par exemple le Gange en Inde, les forêts sacrées, les plantes ou les animaux sacrés.		
Bien-être, loisirs et (éco)tourisme	Plaisir, confort, découverte et socialisation qui se déroulent pendant les loisirs en pleine nature, en observant les éléments naturels.		CDN, 2022 PNA, 2021
Éducation et recherche	Climat, topographie, cycle de l'eau, sol et biote utilisés pour l'éducation et la recherche.		
Appréciation esthétique et inspiration	Perception visuelle des écosystèmes et des paysages.		
	Lacs et rivières représentés dans les chansons, la poésie, les peintures, etc.		

Commentaires :

Nous pouvons observer que sur les 20 processus écosystémiques, 10 sont à risque élevés, 3 sont à risque intermédiaires et 7 sont à risque faibles. Nous remarquons que tous les services écosystémiques de régulation sont à risque élevés et que la majorité des services écosystémiques de soutien sont aussi à risque élevés. A l'inverse, tous les services écosystémiques d'approvisionnement et la majorité des services écosystémiques culturels sont à faible risque.

Nous pouvons constater que seulement 5 processus écosystémiques sur 20 sont mentionnés dans le CDN, deux dans les services écosystémiques de soutien et un dans les autres catégories. Concernant le PNA, 9 processus écosystémiques sur 20 apparaissent dans ce document. Au total, en jumelant les deux documents nationaux, 10 processus écosystémiques sur 20 sont présent dans ces rapports. Il y a donc des chevauchements et des similarités au regard des processus écosystémiques abordés dans ces deux documents.

Parmi les 10 processus écosystémiques mentionnées dans les deux documents nationaux, sept sont consacrés à des processus écosystémiques à risque élevé, deux à risque faible et un à risque intermédiaire. Par conséquent, parmi les 10 processus écosystémiques à risque élevés, seulement trois ne figure pas dans les documents nationaux passé en revu. Parmi les trois processus écosystémiques à risque intermédiaire, seulement un était mentionné dans les plans nationaux.